PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

VOL. III. 1854–5. No. 45.

SEVENTY-SECOND SESSION.

Monday, 4th December 1854.

RIGHT REV. BISHOP TERROT, V.P., in the Chair.

The following Communications were read :—

1. Farther Experiments and Remarks on the Measurement of Heights by the Boiling Point of Water. By Professor J. D. Forbes.

This paper is in continuation of one printed in vol. xv. of the Royal Society's Transactions. The object of it is to test the correctness of the method of observation, and of calculating the results, there proposed; and to compare both with those of more recent authors, particularly of M. Regnault of Paris, and of Dr Joseph Hooker.

The author finds the results of his subsequent observations in 1846 in the Alps, up to heights considerably above 10,000 feet, to agree well with those previously published, made in 1842. They combine in showing a sensibly uniform fall of the boiling point at the rate of 1° for 543 feet of ascent,* which differs only 6 feet (in defect) from his previous determination. The average deviation of the in-

* In a standard atmosphere at 32° of temperature.

dividual results from the formula is only $\frac{1}{12}$th of a degree (without regard to sign).

Barometer.	Boiling Point.	Difference from my formula.	Difference from Regnault's Formula.
Inches.	Fahr.		
20·77	194°·28	+0°·22	+0°·32
20·79	194·33	−0·08	+0·01
22·40	197·94	−0·04	+0·12
22·67	198·51	−0·08	+0·06
23·15	199·52	−0·07	+0·06
23·35	199·94	+0·01	+0·15
23·89	201·04	−0·11	+0·03
23·99	201·24	−0·09	+0·08
24·02	201·31	+0·04	−0·20
24·105	201·47	−0·17	+0·03
25·14	203·51	+0·04	+0·19
28·49	209·54	−0·07	−0·06

The agreement with M. Regnault's table is also extremely close; and considering the ordinary limits of error of such observations, the writer considers it nearly indifferent for elevations under 13,000 feet which method of calculation be used.

The consistency of the results shows that the method of observation (which differs in some respects from that commonly used) and the graduation of the thermometers were satisfactory.

On carefully examining Dr Joseph Hooker's detailed results (obligingly communicated by him), which that naturalist considered to be incompatible with Professor Forbes's formula, it is shown that the inconsistencies of observation are so considerable, that it is difficult to give a decided preference to one formula rather than another, for the purpose of representing them; but that up to heights of at least 13,000 feet, a *linear* formula, or one which assumes the lowering of the boiling point to be exactly proportional to the height, seems to express the observations as well as any other; and the rate of diminution is almost the same as that deduced from Professor Forbes's observation, or a lowering of 1° for 538 feet of ascent.

The author has little doubt that M. Regnault's table (which was not published when he last wrote) does really represent the law according to which water boils more accurately than the simpler linear formula, though the difference is in most cases insensible. For all ordinary heights (or up to 12,000 feet) Regnault's table may be more accurately represented by the formula

$$h = 535\ \mathrm{T}.$$

Where h is the height in English feet, T the lowering of the boiling point in Fahrenheit's degrees, reckoning from 212°. But he

finds that Regnault's table may be represented in every case which can occur in practice, and with almost perfect accuracy, by the following formula, which it is nearly as easy to use :—

$$h = 517\ T + T^2.$$

2. On the Chemical Equivalents of Certain Bodies, and the Relations between Oxygen and Azote. By Professor Low.

The following Gentleman was duly elected an Ordinary Fellow :—

JAMES COXE, M.D.

The following Donations to the Library were announced :—

Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. XVI., Part 1. 8vo.

A Descriptive Catalogue of the Historical Manuscripts in the Arabic and Persian Languages, preserved in the Library of the Royal Asiatic Society of Great Britain and Ireland. By William H. Morley, M.R.A.S. 8vo.

Essay on the Architecture of the Hindús. By Rám Ráz. Published for the Royal Asiatic Society of Great Britain and Ireland. 4to.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1853. IV. Jahrgang. Nro 4. October, November, December. 8vo.—*From the Institute.*

Mémoires de l'Académie Impériale des Sciences, Belles Lettres et Arts de Lyon. Classe des Lettres. Tome II. 8vo.

Mémoires de l'Académie Impériale des Sciences, Belles Lettres et Arts de Lyon. Classe des Sciences. Tome II. 8vo.—*From the Society.*

Annales des Sciences Physiques et Naturelles d'Agriculture et d'Industrie publiées par la Société Impériale d'Agriculture, &c. de Lyon. 2me Série. Tome IV. 1852. 8vo.—*From the Society.*

Mémoires présentés par divers savants à l'Académie des Sciences de l'Institut Impérial de France, et imprimés par son ordre. Sciences Mathématiques et Physiques. Tome XII. 4to.—*From the Institute.*

Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. Tweede Verzameling. 4^{e}, 9de, 10de, & 11de Deel, 1ste Stuk. 4to.—*From the Society.*

Philosophical Transactions of the Royal Society of London. 1852, Parts 1 and 2; 1853, Parts 1, 2, 3; 1854, Part 1. 4to. —*From the Society.*

Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam. 1ste Deel. 4to.—*From the Academy.*

Det Kongelike Danske Videnskabernes Selskabs Skrifter. Femfte Reeke. Naturvidenskabelig og Mathematisk Afdeling. B^{d} 3. 4to.—*From the Society.*

Abhandlungen, herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. 1^{e} B^{d} 1^{e} Lieferung. 4to.—*From the Society.*

Astronomical and Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1852. 4to. —*From the Royal Society.*

Natural History of New York. Palæontology of New York. By James Hall. Vols. I. and II. 4to.

——— Agriculture of New York. By Ebenezer Emmons, M.D. Vols. I. II. and III. 4to.—*From the State of New York.*

Magnetical and Meteorological Observations made at the Honourable East India Company's Observatory, Bombay, in the year 1850. 4to.—*From the Hon. East India Company.*

Astronomical Observations made at the Observatory of Cambridge. Vol. XVII., for 1846, 1847, and 1848.—*From the Observatory.*

Mémoires Couronnés et Mémoires des Savants étrangers publiées par l'Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique. Tome XXV. 1851–53. 4to.—*From the Academy.*

Annales de l'Observatoire Royal de Bruxelles. Tome X. 4to.—*From the Observatory.*

Compte rendu des Travaux du Congrès Général de Statistique, réuni à Bruxelles, les 19, 20, 21 et 22 Septembre 1853. Par A. Quételet. 4to.—*From the Author.*

Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome XIII., 2^{me} Partie. 4to.—*From the Society.*

Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. B^{d}. 7. 4to.—*From the Academy.*

Tables du Soleil exécutées d'après les ordres de la Société Royale des Sciences de Copenhague, par MM. P. A. Hansen et C. F. R. Olufsen. 4to.—*From the Society.*

Rendiconto della Societa Reale Borbonica. Accademia delle Scienze. N.S. N^{ros} 4 & 5. 4to.—*From the Society.*

Atti della Reale Accademia delle Scienze, sezione della Societa Reale Borbonica. Vol. VI. 4to.—*From the Society.*

Transactions of the American Philosophical Society, held at Philadelphia. (N.S.) Vol. X., Part 3. 4to.

Proceedings of the American Philosophical Society. Vol. V., No. 50. 8vo.—*From the Society.*

Researches upon Newerteans and Planarians. By Charles Girard. 1. Embryonic development of Planocera elliptica. 4to.—*From the Author.*

Smithsonian Contributions to Knowledge. Vol. VI. 4to.

Notes on new species and localities of Microscopical Organisms. By J. W. Bailey, M.D. 4to.

Catalogue of the described Coleoptera of the United States. By Frederick Ernest Melsheimer, M.D. 8vo. 2 copies.

Seventh Annual Report of the Board of Regents of the Smithsonian Institution. 1853. 8vo.

The Annular Eclipse of May 26, 1854. Published under the authority of Hon. James C. Dobbin, Secretary of the Navy, by the Smithsonian Institution and Nautical Almanac. 8vo.—*From the Institution.*

Astronomical Observations made during the year 1847 at the National Observatory, Washington. Vol. III. 4to.—*From the Observatory.*

Patent Office Reports, published by the State of Washington. 1851–3. 3 vols. 8vo.—*From the Government of Washington.*

Transactions of the Wisconsin State Agricultural Society. 1851 and 1852. 8vo.—*From the Society.*

Medico-Chirurgical Transactions. Published by the Royal Medica and Chirurgical Society of London. Vol. XXXVII. 8vo.—*From the Society.*

The Philosophy of Physics, or Process of Creative Development. By Andrew Brown. 8vo.—*From the Author.*

Bulletin de la Société Impériale des Naturalistes de Moscou. 1852, Nros 2, 3, & 4; 1853, Nros 1 & 2. 8vo.—*From the Society.*

Novorum Actorum Academiæ Cæsareæ Leopoldino-Carolinæ Naturæ Curiosorum. Vol. XXIV. Pars 1. 4to.—*From the Academy.*

Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. 1853. 4to.

Monatsbericht der Königl. Preuss. Akademie der Wissenschaften zu Berlin. August 1853—Juli 1854. 8vo.—*From the Academy.*

Nachrichten von der Georg-Augusts-Universität und der Konigl. Gesellschaft der Wissenschaften zu Göttingen. 1853. 12mo. —*From the Society.*

Studien des Göttingischen Vereins Bergmannischer Freunde. In namen desselben herausgegeben von J. F. L. Hausmann. Bd 1, heft 3. 8vo.—*From the Editor.*

Siluria. The History of the oldest known Rocks containing Organic Remains, with a brief sketch of the distribution of Gold over the Earth. By Sir R. I. Murchison. 8vo.—*From the Author.*

Museum of Practical Geology and Geological Survey. Records of the School of Mines and of Science applied to the Arts. Vol. I., Part 4. 8vo.—*From the Museum.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. (N.S.) Nos. 45 and 46. 8vo.—*From the Society.*

Proceedings of the Architectural Institute of Scotland. Session 1853–54. 8vo.—*From the Institute.*

Twenty-first Annual Report of the Royal Cornwall Polytechnic Society. 1853. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVII., Part 2. 8vo.—*From the Society.*

The Assurance Magazine, and Journal of the Institute of Actuaries. Vol. V., Part 4, and Vol. V., Part 1. 8vo.

List of Members of the Institute of Actuaries of Great Britain and Ireland. 1854–5. 8vo.—*From the Institute.*

Athenæum. Rules and Regulations, Lists of Members, and Donations to the Library, 1852, with Supplement for 1853. 12mo. —*From the Athenæum.*

Monday, 18th December 1854.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read:—

1. Some Observations on the Salmonidæ. By John Davy, M.D., F.R.S., Lond. and Edin., Inspector-General of Army Hospitals.

These observations are given in seven sections:—

In the 1st, the author treats of the air-bladder of these fish, and the contained air, which he found, in every instance that he examined it, to be chiefly azote.

In the 2d, he points out a mistake he had fallen into in the instance of the female fish, as regards its abdominal aperture, which, in a former paper he had described as open only for the passage of the ova; on further examination made on the larger species, he has ascertained, that though virtually closed, except during the spawning time, it is not absolutely, either by a membrane or adhesion.

In the 3d, on the breeding localities of the Salmonidæ, he states his opinion, that running water is not essential to the hatching of the ova, and he adduces instances in proof and illustration.

In the 4th, which is on the variable time of the hatching of the ova, he describes examples of difference as to time of the production of the young fish under circumstances apparently identical, or circumstances only very slightly different, tending to show the influence of a *vis insita* in the several ova.

In the 5th, on circumstances and agencies likely to take effect on the young fish, he notices two trials,—one on keeping the young fish in darkness after quitting the egg, which had no marked influence; the other, on keeping them in the smallest portion of water capable of covering them, in relation to the position of young fish during a time of drought; in one experiment life was protracted 52 hours, in another 74.

In the 6th, on the food of the young fish, he endeavours to prove that the food most suitable for them, and for which they are best

fitted, is the infusoria. Young charr, under his observation, attained their perfect form and became fit to be set at large, to which no food had been given, and were, it is presumed, after the absorption of the yolk, fed and nourished by these microscopic animalcules.

In the last section, he submits some remarks on the vexed question of the Parr, viewed as a species, and comes to the conclusion that till a parr is found propagating its kind, proof must be held to be wanting of the existence of such a fish, a true species distinct from the salmon or sea-trout fry.

2. On the Structural Character of Rocks. Part III., embracing Remarks on the Stratified Traps of the neighbourhood of Edinburgh. By Dr Fleming.

The author referred, in the first instance, to the character of stratification, illustrating the subject by specimens displaying the intermittent character of the carrying agent and of the supply of material, pointing out the Hailes Quarry as furnishing the best example in the neighbourhood of the repetitions of strata. He then stated the views of Townson, Whitehurst, and Jameson, as to the relation of the trap rocks to the sandstones with which they are interstratified. He then took notice of a statement in vol. xiii. of the Transactions of the Society, recorded by Lord Greenock, that Edinburgh may be considered as a *valley of elevation*, the trap rocks in the neighbourhood dipping outwards as from a common centre. This opinion, he stated, was true in reference to the rocks on the east and west sides of the city, but not true as to those on the south and north, or at Blackford and Burntisland.

Dr Fleming then stated that there were nine masses of trap in the neighbourhood, included in the sandstones, all of them having some peculiar structural characters—viz. Calton Hall, Salisbury Crags, Arthur's Seat, Lochend, Hawkhill, Blackford, Craiglockhart, Corstorphin, and Granton. At this part of the paper he made some remarks on the so-called "outburst of trap" of Inchkeith, stating that the island consisted of at least a dozen of beds of trap alternating *regularly* with acknowledged sedimentary beds of sandstone, shale, and limestone, containing organic remains.

The author then commenced his survey of the stratified traps of

the neighbourhood, by considering particularly the structural character of the Calton, or, as it was termed at an earlier period, the Caldton. This trappean mass he regarded as extending from Greenside to Samson's Ribs, including Heriot Mount, St Leonard's, and the Echoing Rock. The Calton-hill had been described by Townson, Faunas St Fond, Jameson, Webster, Boué, Saussure, Cunningham, Milne, and Maclaren.

Dr Fleming then illustrated his views of the sedimentary character of the whole hill, by tracing on the Ordinance map the coloured spaces occupied by the twelve beds of which the hill consists, assisted by a coloured section. The peculiarities of each bed in regard to its structure and mineral contents were pointed out; and he concluding by noticing the four concretionary masses of *columnar basalt* distributed in the deposit, and the more interesting of the simple minerals of the hill, especially the Sarcite of Townson, first characterized from Calton specimens and afterwards known as Cubizite and Analcime, exhibiting a specimen which he had procured from the hill when a student at the University.

The following Gentleman was duly elected an Ordinary Fellow:—

ERNEST BONAR, Esq., Castle Dobel, Styria.

The following Donations to the Library were announced:—

Archæologia; or, Miscellaneous Tracts relating to Antiquity, published by the Society of Antiquaries of London. Vols. XXXII., XXXIII., XXXIV., XXXV. 4to.

Proceedings of the Society of Antiquaries of London. Vols. I., II.; Vol. III., Nos. 37–40. 8vo.

Catalogue of Roman Coins collected by the late Rev. Thomas Kerrich, M.A., F.S.A., Prebendary of Wells and Lincoln; and presented by his Son, the Rev. Richard Edward Kerrich, M.A., F.S.A., to the Society of Antiquaries of London. 8vo.

List of the Society of Antiquaries of London, on 23d April 1854. 8vo.—*From the Society.*

Memorie della Academia delle Scienze dell' Istituto di Bologna. Tomo IV. 4to.—*From the Academy.*

Neue Denkschriften der Allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. Band XIII. 4to.

Actes de la Société Helvétique des Sciences Naturelles. Réunie à Sion, les 17, 18, et 19 Août 1852. 8vo.

Actes de la Société Helvétique des Sciences Naturelles. Réunie à Porrentray, les 2, 3, et 4 Août 1853. 8vo.

Mittheilungen der Naturforschenden Gesellschaft in Bern. Nros 258–313. 8vo.

Ueber die Symmetrische Verzweigungsweise dichotomer Inflorescenzen. Von H. Wydler. 8vo.—*From the Society.*

Abhandlungen der Historischen Classe der Koeniglich Bayerischen Akademie der Wissenschaften. Bde 7. 1ste Abtheil. 4to.

Gelehrte Anzeigen herausgegeben von Mitgliedern der K. Bayerischen Akademie der Wissenschaften. Bd 36, 37. 4to. —*From the Academy.*

Bulletin de la Société de Géographie. 4me Serie. Tome VII., 8vo. —*From the Society.*

Bulletins de l'Académie Royale des Sciences, des Lettres, et des Beaux Arts de Belgique. Tome XX. 3e Partie. Tome XXI. 1re Partie. Annexe aux Bulletins, 1853–4. 8vo.—*From the Academy.*

Transactions of the Pathological Society of London. Vol. V. 8vo. —*From the Society.*

Proceedings of the Literary and Philosophical Society of Liverpool, during the 43d Session, 1853–54. No. 8. 8vo.—*From the Society.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Vol. XVIII. Nos. 52, 53, 54. 8vo.—*From the Editors.*

The Quarterly Journal of the Geological Society. Vol. IX., Part 1. Vol. X., Parts 2 and 3. 8vo.—*From the Society.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1854. No. 1, Jan. Feb. Marz. (2 copies.) 8vo.—*From the Institute.*

Rendiconto della Societa Reale Borbonica. Accademia delle Scienze. N.S. (Jan.–June, 1853.) 4to.—*From the Society.*

Repertorio Italiano per la Storia Naturale. Repertorium Italicum complectens Zoologiam, Mineralogiam, Geologiam, et Palaeontologiam. Cura J. Josephi Bianconi. Vol. I. 8vo.—*From the Author.*

Jahresbericht über die Fortschritte der reinen, Pharmaceutischen und Technischen Chemie, Physik, Mineralogie und Geologie, herausgegeben von Justus Liebig & Hermann Kopp. 1853. 8vo.—*From the Editors.*

Universalità dei mezzi di previdenzi, difesa, e salvezza per le calamita degl' incendi opera premiata in concorso dalla Accademia delle Scienze dell' Istituto di Bologna. Scritta da Francisco del Guidice. 8vo.—*From the Author.*

Bulletins de la Société Vaudoise des Sciences Naturelles. Tome III. Nos. 25–28, 30, 31, 32. 8vo.—*From the Society.*

Proceedings of the Academy of Natural Science of Philadelphia. Vol. III. Nos. 3–6. 8vo.—*From the Society.*

Notices of the Meetings of the Members of the Royal Institution of Great Britain. Part 4. Nov. 1853–July 1854. 8vo.—*From the Society.*

Report of the Commissioner of Patents for the year 1853. Part I. Manufactures.—*From the Government of Washington, U. S.*

The Annular Eclipse of May 26, 1854. Published under the authority of Hon. James C. Dobbin, by the Smithsonian Institution and Nautical Almanac. 8vo.

Seventh Annual Report of the Board of Regents of the Smithsonian Institution for the year 1852. 8vo.—*From the Institution.*

Exploration of the Valley of the Amazon, made under the direction of the Navy Department. By William Lewis Herndon and Lardner Gibbon. Part 1. By Lieut. Herndon.—*From the Author.*

Transactions of the Cambridge Philosophical Society. Vol. I. Part 3. 4to.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVI. Part 3. 8vo.

General Index to the first fifteen volumes of the Journal of the Statistical Society of London. 8vo.

List of Fellows of the Statistical Society of London. Session 1854-1855. 8vo.—*From the Society.*

Memoirs of the Royal Astronomical Society. Vol. XXII. 4to.—*From the Society.*

Journal of the Horticultural Society of London. Vol. IX. Parts 2 and 3. 8vo.—*From the Society.*

Journal of the Asiatic Society of Bengal. Edited by the Secretaries. Nos. 237–242. 8vo.—*From the Society.*

Mémoires de la Société Impériale des Sciences de l'Agriculture et des Arts de Lille. 1853. 8vo.—*From the Society.*

Die Fortschritte der Physik in den Jahren 1850 und 1851. Dargestellt von den Physikalischen Gesellschaft zu Berlin. 6 & 7 Jahrgang. 1[to] Abtheil. 8vo.—*From the Society.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe. B[de]. XI. & XII. 8vo.—*From the Society.*

Address to the Boston Society of Natural History. By John C. Warren, M.D. 8vo.—*From the Author.*

Monthly Notices of the Royal Astronomical Society. Vol. XIII., 1852–3. 8vo.—*From the Society.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Vol. XVII., No. 51. 8vo. —*From the Editors.*

Tuesday, 2d January 1855.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read :—

1. Notes on some of the Buddhist Opinions and Monuments of Asia, compared with the Symbols on the Ancient Sculptured "Standing Stones" of Scotland. By Thomas A. Wise, M.D.

The general identity, in idea and design, of the ancient monuments of southern and western Europe with those of Hindostan, was shown and illustrated by drawings of cairns, barrows, kist-vaens, cromlechs, circles of stones, and obelisks, or, as they are frequently called, standing stones, as found in both regions. The connection between the inhabitants of these regions was further shown by the physical conformation of the races, by the similarity of many of their manners, customs, and observances, and by the decided and extensive affinity of the Celtic, and other languages of western Europe, with the Sanscrit. The early connection which thus appears to have existed

was shown to indicate a line of inquiry, by following which much of the obscurity, resting over the earliest monuments and history of western Europe, may be cleared away. In particular, reasons were adduced for believing that the widely different doctrines of Buddhism, originating in Asia, at a period when some intercourse was still maintained between the cognate but widely separated races, were carried westward by missionaries, who, finding the people unprovided with a written language, had recourse to symbols, already used in the East, to express their fundamental doctrines. The deity or spirit (Buddha) was designated, as in India, by a wheel or circle; inorganic matter (Dharma) by another circle, or by a monogram, formed of the initial letters of the elements; and organic matter (Sangha) by some embryotic form of animal or vegetable life, or by a circle, or an imperfect crescent. The symbol of three single circles is found in both regions: This triad is found in India in the temple of Ellora, and other Buddhist temples, and in Scotland on the Kineller stone. In the progress of advancement of the arts these simple forms of symbols were changed for temples, and idols were added by the rich and powerful Buddhists of Asia.

Among the ruder and more ignorant inhabitants of Scotland, the arrangement of the symbols required to be altered, to suit the people for whom they were intended: Spirit and Matter continued to be represented by two circles, but connected by a belt, and crossed by a bar uniting the extremities of two sceptres, to indicate the supreme power of these (according to the Buddhist creed) co-ordinate and all-originating principles; while organised matter was represented by a crescent, flower, a dog-like embryo, or some other rude representation of life.

The modifications of the serpent figure, and the Buddhist cross or sacred labyrinth, as symbols of the spiritual deity; and the occurrence of lions, camels, centaurs, with the honour paid to trees, &c., on the ancient sculptured obelisks of Scotland, were also adduced as proofs of an oriental origin, or connection.

Reasons were given for the number of these stones in that part of Scotland forming the ancient Pictish kingdom; of which the inhabitants, after a temporary profession of Christianity, seemed to have declined from the faith.

2. Note on the extent of our knowledge respecting the Moon's Surface. By Professor C. Piazzi Smyth.

Taking advantage of the special attention paid at present to certain astronomical disquisitions, the author called attention to a particular point connected with the moon, which was first stated by the author of "The Plurality of Worlds," and then made by him to prove that the moon must be uninhabited, and thence to lead to the conclusion that all the other planets were uninhabited also. This point was, that "observations having been made on the moon abundantly sufficient to detect the change caused by the growth of such cities as Manchester and Birmingham, no such changes having been perceived, the theory of non-habitation may be indulged in."

But after having indicated the sort of appearance that those collections of human habitations would make when transferred to the moon, Professor Smyth proceeded to show that the registered and published observations of the moon are by no means sufficiently accurate to be used to test this question: and that they do show changes, and often to a far greater amount than the mere building of a lunar Manchester would occasion: but such changes bear the impress of error of observation. More powerfully still was this brought out, on comparing even the best of the published documents with some manuscript drawings of the Mare Crisium in the moon, recently made at the Edinburgh Observatory; and the author hoped that this statement of the imperfection of existing maps would lead to observers generally applying themselves to improve this important and interesting field of astronomy.

3. On the Interest strictly Chargeable for Short Periods of Time. By the Rev. Professor Kelland.

Considerable attention has of late been bestowed on the equitable mode of computing the interest which ought to be charged for fractional portions of a year. Various opinions have been offered relative to the solution of the problem. The basis on which they mutually rest, and on which it appears to me that every solution of the problem must rest, is this—"That the interest chargeable for any fractional part of a year shall at the end of the year amount to a

sum which bears the same proportion to the whole annual interest that the period bears to the whole year." But there are considerations affecting, not the interest, but the principal, which enter largely into the solution of the problem. The date at which both interest and principal are due is the end of the year; it is evident, therefore, that not only ought a less half-year's interest to be paid at the end of the first six months than at the end of the second, but also that the principal itself, if repaid at the end of the first six months, is less valuable for the next period than it would have been if suffered to complete its year. The solution of the problem has accordingly been made to depend on the following assumption—"That both principal and interest recommence a new year at the date of the payment of the latter." I believe I am correct in saying that this is the form in which the problem is usually solved, and I have no objections to make to it; but I can conceive circumstances, in connection with life assurance payments, to which it is not strictly applicable; and I have thought that it would not be unacceptable to those who take an interest in the subject, if I presented the solution of the problem in a new form, obtained by viewing it in another light. With the practical bearing of any solution, I have no concern; it is the province of the actuary to ascertain, in any case presented to him, whether the one or the other hypothesis is applicable. But I do not think it would be difficult to point out examples of the operations of banks and life assurance companies where the interest must be regarded as simply the payment of a sum before it has become due, the capital out of which that sum has accrued being continued in its steady progress to the end of the year. However this may be, whether the problem have a practical bearing or not, it is easy to see the propriety of the following hypothesis as the basis of a theoretical solution of the question—"That the interest chargeable for short periods of time may be deduced from considerations which affect the interest alone." This hypothesis obviously presents us with the following problem, which we have solved:—

Problem.—To find the interest which must be paid at the end of a fractional portion of a year, so that, being presumed to accumulate at the same rate and in the same way in which it has itself been produced, it shall, at the end of the year, amount to the exact portion of the whole annual interest which would then have been payable. For example, to find the interest of L.100 for a quarter

of a year at 4 per cent., so that, at the end of the year, it shall, by accumulating in the same way, amount to L. 1.

Let the interest of L. 1 for a year, payable at the end of the year, be i; and let the interest for the first xth portion of a year, payable at the end of the period, be I_x, then, we ought to have—

$$I_x (1 + I_{1-x}) = x\,i$$

$$\text{or,} \qquad I_x + I_x\, I_{1-x} = x\,i \quad . \quad . \quad . \quad (1.)$$

To solve this equation, substitute $1-x$ for x, and there results

$$I_{1-x} + I_x\, I_{1-x} = (1-x)\,i$$

whence, by subtraction,

$$x\,i - I_x = (1-x)\,i - I_{1-x} \quad . \quad . \quad . \quad (2.)$$

This equation shows that the excess of the proportional part of the year's interest above the sum payable is the same for complementary portions of a year.

Substituting the value of I_{1-x} from equation (2), we get

$$I_x^2 + I_x \left\{ 1 + (1-x)\,i - x\,i \right\} = x\,i$$

$$I_x = \tfrac{1}{2} \left\{ 2\,x\,i - (1+i) \right\} + \tfrac{1}{2}\sqrt{(1+i)^2 - 4\,x\,i\,(1-x)\,i}$$

$$= x\,i - \frac{1+i}{2} \left\{ 1 - \sqrt{1 - \frac{4\,i^2}{1+i^2}\,x\,(1-x)} \right\}$$

The following Gentleman was duly elected an Ordinary Fellow :—

JAMES B. FRASER, Esq., Glasgow.

The following Donations to the Library were announced :

Flora Batava. 176 Aflevering, 4to.—*From the King of Holland.*

Transactions of the Architectural Institute of Scotland. Vol. III., Part 1. 8vo.—*From the Institute.*

Magnetische Ortsbestimmungen ausgeführt an verschiedenen Puncten des Konigreichs Bayern und an einigen auswartigen Stationen. Von Dr J. Lamont. 1 Theil. 8vo.

Annalen der Königlichen Sternwarte bei München. VI. Band. 8vo.—*From the Observatory.*

A Monograph of the British Nudibranchiate Mollusca; with figures of all the species. By Joshua Alder and Albany Hancock. Part 6. 4to.—*From the Ray Society.*

Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. N. S., No. XLVII. 8vo. *From the Society.*

Almanaque Nautico para el año 1855. (San Fernando.) 8vo.—*From the Marine Observatory of San Fernando.*

Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt 1853. No. 3. (Juli, August, September.) 8vo.—*From the Institute.*

Transactions of the Royal Scottish Society of Arts. Vol. IV., Part 2. 8vo.—*From the Society.*

Proceedings of the Royal Society. Vol. VI., Nos. 91–101. 8vo.—*From the Society.*

Boston Journal of Natural History, containing Papers and Communications read before the Boston Society of Natural History, and published by their direction. Vol. VI., No. 3. 8vo.

Proceedings of the Boston Society of Natural History. Jan. 1, 1851—Nov. 16, 1853. 8vo.—*From the Society.*

Proceedings of the American Academy of Arts and Sciences. Vol. III., pp. 1–104. 8vo.—*From the Academy.*

Monday, 15th January 1855.

Dr TRAILL, Curator of the Library, in the Chair.

The following Communications were read :—

1. Some additional Experiments on the Ethers and Amides of Meconic and Comenic Acids. By Henry How, Esq. Communicated by Dr Anderson.

The author commenced by alluding to his analysis of amidomeconic acid in a previous paper, and to the objections urged against the formula he had assigned to it.

By referring to his former analyses, and to a later one, he showed that the empirical formula of the acid could not be that suggested by Messrs Wurtz and Gerhardt, but that his results could only lead to that which he had formerly given, namely—

$$C_{84}\,H_{39}\,O_{78}\,N_7.$$

The discovery of a new ammonia salt of this acid, differing from the yellow one formerly described, has led him to modify the rational formula of the acid; and he now gives for the acid and its two ammonia salts the formulæ,

Meconamidic acid,	$6\,HOC_{84}\,H_{24}\,N_7\,O_{63}+9\,HO.$
Yellow ammonia salt,	$6\,NH_4\,OC_{84}\,H_{24}\,N_7\,O_{63}+3\,NH_3+6\,HO.$
White do. do.,	$6\,NH_4O,\ C_{84}\,H_{24}\,N_7\,O_{63}.$

He added, however, that these formulæ deviated much from what analogy would lead us to expect; and that this want of analogy with other compounds could only be cleared up by farther investigation.

He then described an amide, biamidomeconic acid, obtained by the action of ammonia on biethylated meconic acid. Its formula is—

$$HOC_{14}\,H_5\,N_2\,O_9+Aq.$$

He mentioned also the formation of a black oily substance, possibly the triethylated meconic acid.

The next section of the paper treated of the action of iodide of ethyle in comenic acid, which yields the substance formerly described as comenamic or ethylocomenic acid,—

$$HOC_4\,H_5\,OC_{12}\,H_2\,O_8.$$

This the author considers to be the true comenic ether. On trying to obtain an analogous amyle compound, he obtained what seemed to be the same ethyle compound.

He next stated that comenic acid, heated to 300° F. with water for some days, undergoes entire decomposition, the products being carbonic acid, and a shining black solid, not yet examined.

He then described the action of hydrochloric acid on comenic acid and alcohol, which yield a curious compound, which crystallizes in long silky needles, and the formula of which is—

$$C_4\,H_5\,OC_{12}\,H_4\,NO_7,\ 2\,HO+HCl.$$

It is readily decomposed, yielding comenamic ether. It is therefore a compound of that ether with hydrochloric acid.

Comenamic ether is readily obtained from it by the action of ammonia on its hot aqueous solution. The ether forms colourless prisms, the formula of which is—

$$C_4\,H_5\,OC_{12}\,H_4\,NO_7.$$

By nitric acid it is converted into binoxalate of ammonia. When heated, it melts at above 400° F., and on cooling, concretes to a crystalline mass, or sometimes takes the form of a pillared solid mass.

The paper concludes with a tabular list of the compounds described in it, with their formulæ.

2. On a Revision of the Catalogue of Stars of the British Association. By Captain W. S. Jacob, H.E.I.C., Astronomer at Madras. Communicated by Professor C. Piazzi Smyth.

After a brief allusion to the importance of catalogues of stars in general, as the foundation of exact astronomy, the circumstances connected with the publication of the important Catalogue of Stars by the British Association were mentioned.

Many of the materials were well known to be imperfect at the time of printing, but that step, it was thought, would strongly induce all astronomers to improve the defective portions.

This has since been found to be the case extensively, and the present paper is an important contribution to that end.

After mentioning his practical methods of ensuring the greatest possible accuracy, Captain Jacob describes the result of an examination of 1503 out of the 8377 stars of which the Catalogue of the Association consists, and states that the large number 55 are altogether missing in the sky, that 71 differ from their computed places by more than 2 sec. of time, or 10″ of N.P.D.; but that the rest are all very exact, seldom differing by more than 0·2 of a second of time.

Some of the above cases of large difference, he thinks caused by proper motion, and recommends further observations at a future period, to settle the question.

3. Notice of Ancient Moraines in the Parishes of Strachur and Kilmun, Argyleshire. By Charles Maclaren, F.R.S.E.

The first of the moraines referred to is in Glensluan, a valley near Strachur, about two miles and a half in length, and two-thirds of a mile in breadth. It is bounded on the east, west, and south

sides by mountains from 800 to 2000 feet in height. At the north or lower end, where it opens into Glen Eck, there is a series of mounds of clay and gravel, crossing the valley like embankments, and spread over a space of about 1800 feet in length, and from 350 to 600 in breadth. They are from 20 to 100 feet in depth. These mounds have turned the river Sluan from its direct course down the middle of the valley, and forced it to cut a passage towards the east side. They consist of piles of incoherent clay and gravel, mixed with blocks, all derived from the rock (mica slate) which bounds the valley. In form, materials, and position, they exactly resemble the terminal moraines found at the foot of valleys occupied by glaciers; and if found in a similar situation in the Alps, would be at once recognised as terminal moraines.

The other moraines are in Glenmessan, about 10 miles southward from Glensluan. They consist, first, of two mounds of clay and gravel, mingled with blocks, stretching across the foot of Glenmessan like embankments, and of the height of 40 and 77 feet respectively; secondly, of four other detached mounds, from 25 to 30 feet in height, scattered over a small plain or meadow, half a mile farther south. In the valley of Glenmessan, grooved rocks, and other marks of glacial action, are also found, and strengthen the conclusion, that a glacier once occupied the valley, and produced the mounds of clay and gravel.

Monday, 5th February 1855.

The Right Rev. Bishop TERROT in the Chair.

The following communications were read:—

1. On the Properties of the Ordeal Bean of Old Calabar, Western Africa. By Dr Christison.

In various parts of Western Africa it appears to be the practice to subject to the ordeal by poison persons who come under suspicion of having committed heinous crimes. On the banks of the Gambia river the poison used for the purpose is the bark of a leguminous tree, the *Fillæa suaveolens* of MM. Guillemin and Perottet. In the neighbourhood of Sierra Leone it is the bark of *Erythrophleum guinëense*,

which some botanists have considered identical with the former species. On the Congo river, Captain Tuckey found that either this species, or an allied species of the same genus, was in constant use for the same purpose. These barks, when their active constituents are swallowed in the form of infusion, sometimes cause vomiting; and then the accused recovers, and in that case is pronounced innocent. More generally the poison is retained; and then the evidence of guilt is at the same time condemnation and punishment; for death speedily ensues.

In the district of Old Calabar, the poison used for the trial by ordeal is a bean, called Eséré, which seems to possess extraordinary energy and very peculiar properties. It has been lately made known to the missionaries sent by the United Presbyterian Church in Scotland to the native tribes of Calabar; and to the Rev. Mr Waddell, one of these gentlemen, the author was chiefly indebted for the materials for his experiments, as well as for information as to its effects on man. According to what the missionaries often saw, this poison is one of great energy, as it sometimes proves fatal in half an hour, and a single bean has proved sufficient to occasion death. None recover who do not vomit it. The greater number perish. On one occasion forty individuals were subjected to trial, when a chief died in suspicious circumstances, and only two recovered.

The author found the bean to present generally the characters of a *Dolichos*. It has been grown at his request both by Professor Syme and at the Botanic Gardens by Mr M'Nab; and it proves to be a perennial leguminous creeper, resembling a dolichos, but it has not yet flowered. The seed weighs about forty or fifty grains. It is neither bitter, nor aromatic, nor hot, and differs little in taste from a haricot bean. Alcohol removes its active constituent, in the former of an extractiform matter, amounting to 2·7 per cent. of the seed. The author could not obtain an alkaloid from it by any of the simpler processes for detaching vegetable alkaloids.

By experiment on animals, and from observation of its effects on himself, the ordeal bean has a double action on the animal body: it paralyses the heart's action, and it suspends the power of the will over the muscles, causing paralysis. It is a potent poison, for twelve grains caused severe symptoms in his own person, although the poison was promptly evacuated by vomiting, excited by hot

water. The alcoholic extract has the same effect and action with the seed itself.

2. Experiments on the Blood, showing the effect of a few Therapeutic Agents on that Fluid in a state of Health and of Disease. By James Stark, M.D., F.R.C.P.

The author stated that when he commenced these experiments, in 1832, his object was to ascertain, *first*, what effect different diseases had on the constitution of the blood; and, *secondly*, what effect various therapeutic agents had on that fluid in a state of health and of disease. As the experiments of Andral and others, published since these experiments were commenced, had done much to elucidate many points of the first subject of inquiry, the author limited this communication to a small portion of the latter inquiry.

The effect of bloodletting on the constitution of the blood in pneumonia was first described. It was shown that each successive bloodletting increased the proportion of fibrin in the blood, which fibrin was already in excess in consequence of the existence of the inflammatory disease. Finding that bloodletting had always this effect in inflammation, the author made experiments on the healthy subject, to ascertain whether bloodletting had any effect on the constitution of the blood, and found that it produced an increase in the proportion of fibrin as compared with the other solids of the blood. On bleeding sheep rapidly to death, the suddenness of the death prevented the increase being very marked; but when the same animals were bled slowly to death, the fibrin in the last drawn blood was found to be nearly a third greater relatively to the other solids of the blood than in the first drawn blood.

To illustrate this part of the subject, the author pointed out the bearing of these experiments in the treatment of a few diseases, as inflammations, apoplexy, hæmoptysis, purpura, and hæmorrhage from a divided blood-vessel; and also their bearing on the phenomena of inflammation.

The effects of alkalies and alkaline carbonates on the blood, and in the treatment of inflammatory affections, was next noticed; after which the author passed to the consideration of another important therapeutic agent—mercury.

He showed that when mercury was administered internally, it

caused a reduction in the proportion of the fibrin of the blood; produced a state exactly the opposite of that caused by inflammation—in fact, caused a state of the blood exactly analagous to that existing in scurvy. He therefore inferred that mercury would prove the most valuable remedy in the treatment of inflammatory diseases; and accordingly, in trying its effects, first in pneumonia, and afterwards in other inflammatory diseases, he found, that just in proportion as the mercury was absorbed, the excess of fibrin in the blood, which had been produced by the inflammation, diminished, and with this diminution all the inflammatory symptoms subsided, and the cure went on satisfactorily. As the object in these cases was to produce a rapid absorption of the mercury, the calomel was given in such small doses as not to act on the bowels (generally the fourth or the sixth of a grain every hour), and in no case was it conjoined with opium.

The paper was concluded by pointing out that these experiments gave no countenance whatever to the doctrines of Hahneman, but confirmed the truth of the adage of Hippocrates, "that contraries are the cure of contraries."

3. Extracts from a Letter from E. Blackwell, Esq., containing Observations on the Movement of Glaciers of Chamouni in Winter. Communicated by Professor Forbes.

"The accessibility of the glaciers, even up to a considerable height, is at this season a question of mere physical force. I have made within the last few days two excursions into the region of perpetual snow. The first of these was on the 6th of January, and was to the summit of the glacier of Blaitière, several hundred feet above the point where I had noted the line of the névé in September and October; the second was on the 13th, when I succeeded in reaching the junction of the glaciers of Bossons and Tacconaz, near the Grands Mulets. This junction is exactly at the commencement of the névé, as I remarked between the months of August and October, on six different occasions, when I passed there on my way to and from Mont Blanc, the Dôme de Gouté, &c. In both these expeditions I was struck by the excessive power of the sun; the greater apparent warmth, even in the shade, as compared to the valley of Chamouni; and the sudden chill which followed sunset. There was also much less snow at

these heights than in the valley, and I have no hesitation in saying that in winter very little snow falls upon the higher summits. The snow-falls in the valley are *invariably* brought by a low creeping fog, which comes up from Sallanches. It seldom overtops the Col de Voza, and the Aiguilles appear bright and sunny in the gaps of the cloud. It is in spring and autumn that these higher peaks are powdered by every storm; *now* the dispersing clouds leave them as dark as before they gathered. I fancy this winter is unusually cold; every one is crying out, and complaining that the potatoes are frozen in deep cellars. I have seen Reaumur's thermometer at — 25° at 5½ in the afternoon, and I think it may reasonably be supposed that it may have fallen to — 30° during the night; wine has frozen on my table before a fire. In the woods the trees crack with the intense frost, and there is from 2½ to 3 feet of snow in the valley without drifts; on the glacier of Blaitière there is only from 1 to 2 feet.

" In spite of all this cold the glaciers advance steadily. The glacier de Blaitière, terminating above the line of trees, pushes its moraine in front of it, and seems to be on the increase. Now this is a very *shallow* glacier, and, as I have said, covered with but little snow. Is it possible that infiltrated water can have any action whatever under such circumstances?

" I will here state a few results of careful observation, and I hope that, even should they appear strange, you will yet consider them worthy of confidence. I have no theodolite, but I have a prismatic compass, and will take the bearings of various points from my stations should you deem it advisable.

" The torrent of Bossons has been quite dry ever since the beginning of November, and I have profited by this circumstance to endeavour to determine the motion of the ice within the vault, nearly in contact with the ground. I believe it is usually supposed that the reason why the termination of a glacier seems stationary in summer, is that there the waste predominates over the supply. It seemed to me, therefore, that in winter, when there is actually no waste—the torrent being perfectly dry, and its subglacial bed even *dusty*—the end of the glacier ought to be thrust forward into the valley by the pressure behind. I accordingly, with some little difficulty, fixed a station on the ridge or back of the glacier, near the lower extremity; the result is, that *the ice there is nearly sta-*

tionary. This is doubtless a clue to the assertions of some authors, 'that the glacier is stationary in winter;'—they only looked at *the end*. What becomes, then, of the ice continually descending from above? Does it not go to thicken the whole mass, accumulating behind the more rigid portion below, as water behind a dam? I have no space to add more at present, but will write again if I have your approval of my proceedings. Meanwhile I have fixed (yesterday) an intermediate station, for the purpose of determining *where* this comparative immobility begins. I have noted my observations, and kept a register of weather, &c. I give one observation to show the difference between the middle and lower glaciers:—

From December 28 to January 11—14 days.

Middle glacier (somewhat above where it is usually crossed).
Centre, 14 ft. 7 in. (fourteen feet, seven inches).
Side, 11 ft. 6 in. (eleven feet, six inches).

Lower glacier during the same period.
Ridge, 1 ft. 7 in. (one foot seven inches).
Interior of vault, 0 ft. 2 in. (two inches)."

Observations on Mr Blackwell's Letter by Professor Forbes.

The cold described (—25° to —30° of Reaumur—24½° to —35½° of Fahrenheit)—appears so excessive as to be unlikely; I have therefore written to enquire if the thermometer could be depended on.

It is highly satisfactory that the superficial velocity of the glacier of Bossons—about a foot in twenty-four hours—coincides closely with the measurements of my guide, Auguste Balmat, some years since, on the same glacier, at the same season.

With respect to the ice of the glacier of Blaitière, which is above the level of trees—probably at least 7000 feet above the sea—being still in motion, it merely confirms the deductions long ago made by me as to the continuity of glacier motion even in winter. And as to the apparent paradox of water remaining uncongealed in the fissures of the ice at this season, though I have nowhere affirmed the presence of liquid water to be a *sine qua non* to the plastic motion of glaciers, it would be difficult to assert positively that it is everywhere frozen in the heart of a glacier even in the depth of winter. Heat, we know, penetrates a glacier (up to 32° and no further), not only by conduction, but much more rapidly by the percolation of water; but cold penetrates *solely* by conduction, and that according to the same law as in solid earth, though it may be more

rapidly. Now, it is known that at a depth of 24 or 25 feet in the ground, the greatest summer heat has only arrived at Christmas. A similar retardation in the effects of cold must occur in glaciers. Not a particle of water detained in the capillary fissures can be solidified until its latent heat has been withdrawn.

The contrast the writer draws between the glaciers of Blaitière and Bossons, the latter of which is some thousand feet lower in point of level, is curious and instructive. The former, he says, appears the more active, and is pushing forwards its *moraine ;* whilst the latter, at its lower extremity, and in contact with the ground, is scarcely moving at all.

There is nothing of which we know less than the cause of the seemingly capricious advance and retreat of the extremities of glaciers at the same time and under, seemingly, the same circumstances.

In the present case, I will only mention as a *possible* explanation, that the glacier of Blaitière probably possesses a continuous slope, from its middle and higher region down to its lower extremity. But the Bossons, after its steep descent from Mont Blanc, proceeds a long way on a comparatively level embankment, which at an early period it cast up of its own debris, and in which it has dug itself a hollow bed in which it nestles. The angular slope of the bottom in contact with the soil is very probably much less than in the case of the glacier of Blaitière. Now, when winter has dried up the percolating water, the viscosity of the mass may be insufficient to drag it over the less slope although it carries it over the greater. That the motion of the ice close to the ground should be nearly nothing, whilst the more superficial part of the glacier over-rides it by its plasticity, is as a separate fact quite in accordance both with theory and previous observation.

But as the *snout,* or lower end of the glacier of Bossons, is almost stationary, whilst the middle region is moving at the rate of a foot a day, Mr Blackwell very pertinently asks, "What becomes, then, of the ice continually descending from above? Does it not go to thicken the whole mass, accumulating behind the more rigid portion below, as water behind a dam?" I answer, undoubtedly; and he will find this explanation given ten years ago in my *Travels in the Alps* (2d edit., p. 386.) Speaking of the superficial waste of the glaciers in summer and autumn, and the manner in which it is re-

paired before the ensuing spring, I there observed, "The main cause of the restoration of the surface is the diminished fluidity of the glacier in cold weather, which retards (as we know) the motion of all its parts, but especially of those parts which move most rapidly in summer. The disproportion of velocity throughout the length and breadth of the glacier is therefore less, the ice more pressed together, and less drawn asunder; the crevasses are consolidated, while the increased friction and viscosity causes the whole to swell, and especially the inferior parts, which are the most wasted."—(See also *Seventh Letter on Glaciers*, p. 435 of Appendix to the same work.)

The following Gentleman was elected an Ordinary Fellow:—

Dr Stevenson Macadam.

Monday, 19*th February* 1855.

JAMES TOD, Esq., in the Chair.

The following Communications were read:—

1. On the Mechanical Action of Heat:—Supplement to the first Six Sections, and Section Seventh. By W. J. Macqueen Rankine, Esq., C.E., F.R.SS. Lond. and Edinb.

This paper is written in continuation of a series of papers, of which six sections have already been published in the Transactions of the Royal Society of Edinburgh.

It commences with some articles supplementary to the first six sections, and intended to apply to the theoretical principles contained in them to the extensive and precise experimental data which have been obtained in the course of the last two years.

Article 65 relates to the *Absolute Thermometric Scale* and to *Thermodynamic Functions.* The *Absolute Thermometric Scale* is a scale, the temperatures on which, according to one definition, are proportional to the actual quantity of energy possessed by any given substance in the form of heat, divided by the real specific heat of the

substance, a constant co-efficient, and, according to another definition, are proportional to the tendencies of heat to disappear in producing mechanical effects. These definitions are substantially equivalent. The recent experiments of Messrs Joule and Thomson have confirmed the anticipation, that absolute temperatures, as thus defined, agree with those measured by the variation of pressure of a perfect gas; they have also proved, what could only be conjectured before, that the absolute zeros of heat and of gaseous pressure sensibly coincide. The author, from a revision of M. Regnault's experiments on the elasticity of gases, concludes the most probable value of the absolute temperature of melting ice to be—

$$274^\circ \text{ Centigrade} = 493^\circ{\cdot}2 \text{ Fahrenheit.}$$

Messrs Joule and Thomson, from their experiments on the cooling of gases by free expansion, deduce the value—

$$273^\circ{\cdot}7 \text{ Centigrade} = 492^\circ{\cdot}66 \text{ Fahrenheit.}$$

The difference between those values is practically inappreciable.

A *Thermodynamic Function* is a function of the condition of a substance, such that the heat absorbed by the substance during any small variation of condition represented, in units of work, by the product of the corresponding variation of the thermodynamic function into the absolute temperature. A thermodynamic function consists of two parts. The first is connected with the heat stored up as *actual heat* in the substance, and is simply the product of the real specific heat by the hyperbolic logarithm of the absolute temperature. The second is what has been employed in the previous sections of the paper, and in a paper on the centrifugal theory of elasticity, under the name of *Heat-potential*, being a function the product of whose variation into the absolute temperature represents heat converted into mechanical work.

The complete value of the thermodynamic function for a given substance is,

$$\Phi = \mathfrak{k} \text{ hyp. log. } \tau + \int \frac{dP}{d\tau} \, dV,$$

where $\mathfrak{k}$ is the real specific heat, τ the absolute temperature, P the pressure, and V the volume; and the fundamental equation of the mechanical action of heat, previously given in various forms, may be expressed as follows:—

$$d\cdot H = \tau\, d\cdot\Phi$$

where $d\cdot H$ is the quantity of energy required, in the form of heat, to produce the variation $d.\Phi$.

In article 65·*a*, a new form of the thermodynamic function is pointed out, in which the *pressure* and absolute temperature are taken as independent variables instead of the *volume* and absolute temperature. It is as follows :—

$$\Phi = \left(k + \frac{P_0 V_0}{\tau_0}\right) \text{hyp. log. } \tau - \int \frac{dV}{d\tau}\, dP,$$

and is useful in solving a particular class of questions. P_0 and V_0 are respectively the pressure and volume of the given substance at the absolute temperature τ_0 in the state of perfect gas.

In article 66, the constants in the formulæ deduced from the hypothesis of molecular vortices for the elasticity of *carbonic acid gas* are revised, and adapted to the corrected position of the absolute zero; the result being expressed by the following very simple law :—

The diminution of the elasticity of carbonic acid gas, produced by the mutual attraction of its particles, varies directly as the square of its density, and inversely as its absolute temperature.

These constants are determined solely from the experiments of M. Regnault on the increase of pressure between 0° and 100° Centigrade of carbonic acid gas of constant density, and in the specific gravity and specific heat of the gas. The results of the formulæ are then compared, and found to agree most closely with those of the following sets of experiments :—

1. Those of M. Regnault, on the expansion of carbonic acid gas at constant pressure.

2. Those of M. Regnault, on the compressibility of carbonic acid gas.

3. Those of Messrs Joule and Thomson, on the cooling of carbonic acid gas by free expansion. The results of the last set of experiments were *anticipated* by means of the formula.

General Formula and Constants for Carbonic Acid Gas.

$$\frac{PV}{P_0 V_0} = \frac{\tau}{\tau_0} - \frac{a}{\tau} \cdot \frac{V_0}{V}.$$

$$\left.\begin{array}{l}\text{P pressure in lb. per square foot,} \\ \text{V volume of one lb. in cubic feet,}\end{array}\right\} \begin{array}{l}\text{at the absolute} \\ \text{temperature } \tau\end{array}$$

P_0 = one atmosphere = 2116·4 lb. per square foot.
V_0 = 8·15725 cubic feet.
P_0V_0 = 17,264 foot-pounds.
a = 1·9 for the Centigrade scale.

Specific Heats of One Pound of Carbonic Acid Gas, at the atmospheric pressure, in units of work per Centigrade degree.

At constant pressure, 300·7 foot-pounds.
At constant volume, 235·9 „ „
Real specific heat, 235·0 foot-pounds.

In article 67, the constants, as determined by Messrs Joule and Thomson, of a formula of the same class for *atmospheric air*, but involving a more complicated function of the reciprocal of the temperature, are adapted to the position of the absolute zero adopted in this paper, as follows :—

$$\frac{PV}{P_0V_0} = \frac{\tau}{\tau_0} - \left(a_0 - \frac{a_1}{\tau} + \frac{a_2}{\tau^2}\right)\frac{V_0}{V}$$

$$P_0V_0 = 26{,}248 \text{ in latitude } 45^\circ.$$
$$26{,}238 \text{ in Britain.}$$
$$a_0 = 0{\cdot}0012811$$
$$\left.\begin{aligned} a_1 &= 1{\cdot}3932 \\ a_2 &= 353{\cdot}9 \end{aligned}\right\} \text{for the Centigrade scale.}$$

The SEVENTH SECTION of the paper follows, being on the THERMIC PROPERTIES OF VAPOURS.

Article 68 relates to a principle, the first idea of which was imperfectly suggested by Carnot, and more fully developed by M. Clausius. By the aid of improved knowledge of the laws of the mechanical action of heat, it is now stated as follows :—

The latent heat of evaporation, in units of mechanical work, of so much of a substance as fills, in the state of vapour, unity of space more than it fills in the liquid state, is the differential coefficient of the pressure with respect to the hyperbolic logarithm of the absolute temperature.

In article 69 the new form of the thermodynamic function, given in article 65 *a*, is employed to determine the precise law of variation, with the boiling-point, of the total heat of evaporation from a fixed temperature ; a law of which the approximate form, applicable to a substance whose vapour is a perfect gas, and very bulky as compared

with its liquid, was first investigated by the author in the third section of the paper.

In article 70 there is deduced from the new form of the thermodynamic function, a law called that of the "*Total Heat of Gazefication*," which includes, as a consequence, the law of the total heat of evaporation. The *total heat of gazefication* of a given substance, under constant pressure, between two given temperatures, is the heat which must be communicated to the substance in order to convert it from the liquid or solid state at the lower temperature, to the state of *perfect gas* at the higher temperature,—evaporation taking place at the boiling point corresponding to the constant pressure under which the whole operation is performed. When the bulk of the substance (as is the case for all known substances) is very small in the liquid or solid state, as compared with its bulk in the state of perfect gas, *the total heat of gazefication, under constant pressure, between two given temperatures, does not sensibly vary with the pressure.*

This law is of great importance in connection with the employment of super-heated vapours to drive machinery.

In article 71 are given formulæ, founded on the experiments of M. Regnault, for computing the pressures of the vapours of æther, bi-sulphuret of carbon, alcohol above 0° c., water, essence of turpentine above 40° c., chloroform above 70° c., and mercury up to 358° c. The table of constants for these fluids is extracted from a paper read before the British Association in September 1854, and published in the *Philosophical Magazine* for December 1854.

In article 72, it is shown how these formulæ are applied to calculate the *latent heat of evaporation for unity of space.*

In article 73, it is stated, that if the latent heat of evaporation of unity of weight of a fluid be known by experiment for a given temperature of ebullition, and the latent heat of evaporation for unity of space be computed theoretically, the volume of unity of weight of the vapour at the given temperature of ebullition may be calculated from these data. This principle is applied to the latent heats of evaporation, under atmospheric pressure, of æther, sulphuret of carbon, and alcohol, as determined experimentally by Dr Andrews, and of water, as determined by M. Regnault. The results of these calculations are compared with those of computations founded on the chemical composition of the fluids, and the supposition that their

vapours are perfectly gaseous. The following is a summary of the results:—

Fluids	Æther.	Bi-sulp. of Carbon.	Alcohol.	Water.
Boiling points	35° cent.	46°	78°	100°
Volume of one lb. of vapour as computed—	cubic feet.	cubic feet.	cubic feet.	cubic feet.
From latent heat	5·3968	5·4689	9·366	26·36
From composition	5·3874	5·4643	9·900	27·18

In article 74, the close coincidence of the results of the above computations for æther and bisulphuret of carbon is stated to be a confirmation of the principles deduced from the mechanical theory of heat, and also a proof that the vapours of æther and bi-sulphuret of carbon may be treated in practical calculations, without sensible error, as perfectly gaseous, when at pressures not greatly exceeding one atmosphere. The following are the values of some of the constants for these fluids:—

	Æther.	Bi-sulp. of carbon.
P_0V_0	10,110 ft. lb.	9902 ft. lb.
Specific heat of liquid for centigrade scale,	718·4 „	443·3 „
Specific heat of vapour at constant pressure for centigrade scale,	668·4 „	218·9 „

In article 75, the differences between the results of the two methods of computation for alcohol and water are considered as the effects of deviations of the vapours of these fluids from the perfectly gaseous condition,—deviations which in the case of steam have long been anticipated.

On an Inaccuracy (having its greatest value about 1″) in the usual method of computing the Moon's Parallax. By Edward Sang.

When, as in the usual operation, the moon's observed zenith distance is corrected for the effects of atmospheric refraction, the zenith distance so obtained is that of the rectilineal part of the ray of light between the planet and the upper surface of the air; and on applying that correction, as at the Observatory, we do not obtain the direction of the moon as it would have been seen if there had been no atmosphere, but that of a line drawn parallel to the first part of the ray, and therefore passing below the moon. The true direction of a straight line drawn from the observer to the planet, must differ

from this direction by the angle which the curved part of the ray subtends at the moon's centre; and the neglect of this angle may cause a sensible error in estimating the parallax.

It is a well-known property of refraction by concentric strata, that the perpendiculars let fall from the centre of curvature upon the tangent to the path of light are inversely proportional to the indices of refraction of the medium at the two points of contact.

From this property it very easily follows that the sine of the true parallax is obtained by multiplying the sine of the horizontal parallax by the sine of the observed zenith distance, and by the index of refraction of the air at the Observatory.

And if the horizontal parallax given in the almanac, instead of being the half angle under which the earth would have been seen from the moon if there had been no atmosphere, had been the true horizontal parallax, or half the angle which, in the actual state of things, the earth does subtend at the moon,—the true method of computing the parallax would only differ from the common one in the use of the uncorrected instead of the corrected zenith distance.

In the common formula, the multiplier is the sine of the zenith distance corrected for refraction; in the true formula, it is the sine of the uncorrected zenith distance, multiplied by the index of refraction of the air.

For the purpose of obtaining the maximum error of the common formula, it is observed that when the moon is in the horizon, the zenith distances being nearly 90°, have their sines sensibly equal to each other, and that then the true multiplier must exceed the usual one in the ratio of 3405 to 3404,—this ratio being the index of refraction of air in its mean state; wherefore, at the horizon, the parallax, as usually computed, must fall short of the true parallax by one 3404th part of itself.

This ratio holds good for all planets; and it is only in the case of the moon that the error becomes sensible, being then almost exactly one second of an arc.

The following Gentlemen were elected as Ordinary Fellows:—

1. Robert Etheridge, Esq., Clifton, Bristol.
2. John Inglis, Esq., Dean of Faculty.
3. Rev. James S. Hodson, Rector of the Edinburgh Academy.

Monday, 5*th March* 1855.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read :—

1. On Annelid Tracks in the Exploration of the Millstone Grits in the South-west of the County of Clare. By Robert Harkness, Esq., F.R.S.E., F.G.S., Professor of Geology, Queen's College, Cork.

The author remarks that the existence of Annelida during the Palæozoic formations is manifested in two conditions. In the one, we have the shelly envelope which invests the order Tubicola, in the form of Seapolites; and in the other, the tracks of the orders Abranchia and Dorsi-branchiata are found impressed on deposits which were, at one time, in a sufficiently soft state to receive the impressions of the wanderings of these animals.

Among the strata which have hitherto afforded annelid tracks, those which, in the county of Clare, represent a portion of the equivalents of the Millstone Grit, contain such tracks, in their most perfect state of preservation in great abundance ; and these strata also furnish evidence concerning the circumstances which prevailed during their deposition.

The locality of these strata is the neighbourhood of Kilrush, on the banks of the Shannon, in the southern portion of the county. Here the deposits consist of strata which have a flaggy character; and these have been extensively wrought at Money Point, about four miles east from Kilrush, and they supply the flags which are commonly used in the towns of the south of Ireland. The beds vary somewhat in their nature, and with this circumstance they present different phenomena.

The annelid tracks occur in three conditions. When they are in their most perfect state, in the faces of the higher flags, which are of a greenish gray colour, they have the form of meandering tracks, about half an inch across, and their margins crenated. A distinct raised line traverses the centre of these tracks, and the interval between this line and the crenations is marked by a succession of other

lines at right angles to the centre one; and these seem to have had their origin in the rings of the body of the annelid.

The nature of the tracks as they occur in the lower flags, which are dark-coloured, is somewhat different. On the upper surfaces of these they appear also in the form of sinuous furrows, about the same width as the more perfect tracks of the higher flags. Here, however, they rarely present crenations, being regular on their margin, and having, in many instances, the impression of the ventral arch distinct.

The various appearances of the tracks, and the nature of the strata with which these are associated, furnish some important information concerning the conditions which obtained when this portion of the Millstone Grit series was being deposited. The tracks, from their various states of perfection, indicate that, in some instances, the mud which now constitutes these flags had been in different states, as concerns consolidation, at the time when it was traversed by these animals. It sometimes appears to have been in a state so saturated with water that it assumed a pasty condition, partly flowing in upon the tracks after these had impressed its surface, and obliterating the markings of the cirri. At other times it seems to have been sufficiently consolidated to afford the requisite conditions for more perfect tracks, as in the case of the higher greenish-gray flags.

The animals which impressed these Irish flags appear to have been widely different from those which have burrowed in the deposits which now form the flags of the lower portion of the Lancashire coal-field, since, in these latter, neither the entrance into the burrows nor the burrows themselves, equal the annelid burrows of the flagstone of Clare; the former having only a diameter of one-fifth of an inch, and being apparently round, while the latter are half an inch in breadth, and have their form flattened longitudinally, which gives to them, on transverse section, the lenticular shape already referred to. From their crenulated margins, which would indicate that the cirri were more perfectly developed in the annelids to which we owe these tracks, it would seem that they are more nearly allied to those which have impressed the strata of the older formations, than to such as have left their markings on the English carboniferous deposits; and if we adopt the general appellation of Sir Roderick Murchison, they might be considered as the carboniferous type of the ancient *Nerites*, and be designated *Nerites carbonarius*.

2. On Superposition. By Professor Kelland.

The object of this paper was to defend the method of demonstration employed by Euclid from some of the charges which have been at various times brought against it. In particular, it was shown that the method is not deficient in variety of demonstration of the same fact. This position was illustrated by the exhibition of twelve totally different demonstrations of the problem, "To cut three-fourths of a square into four pieces which shall form a square."

3. On the Colouring Matter of the Rottlera tinctoria. By Professor Anderson, M.D., Regius Professor of Chemistry in the University of Glasgow.

The Rottlera tinctoria is a large tree which is found distributed over the whole Indian peninsula, and is particularly abundant in the hill jungles of Mysore, Canara, and Malabar. The fruit, which is about the size of a pea, is covered with curious stellate hairs and red glands, which are easily separated by rubbing, and form without further preparation the colouring matter which is sold in the bazaars. It is a perfectly uniform brick-dust coloured powder, which repels water, and is scarcely soluble in that fluid. Alcohol and ether extract a red colouring matter, as do also the alkalies and their carbonates. A proximate analysis showed it to contain—

Water,	3·49
Resinous colouring matters,	78·19
Albuminous matters,	7·34
Cellulose, &c.,	7·14
Ash,	3·84
	100·00

The colouring matters consist of at least three different substances.

1. A crystallizable matter extracted by ether, to which the author gives the name of Rottlerine. It forms a mass of yellow crystalline scales, having a fine satiny lustre. Insoluble in water, sparingly soluble in alcohol, and readily in ether. It dissolves in alkaline solutions with a deep red colour, but does not form definite compounds with the metallic oxides. It is decolorized by bromine with the pro-

duction of a substitutive product which does not crystallize, and cannot be obtained pure. Its analysis gave as the mean of four closely concordant experiments—

	Mean.	Calculation.		
Carbon, .	69·112	69·47	C_{22}	132
Hydrogen, .	5·550	5·26	H_{10}	10
Oxygen, .	25·333	25·27	O_6	48
	100·000	100·00		

corresponding with the formula $C_{22}\,H_{10}\,O_6$; but the impossibility of forming compounds renders it impossible to ascertain whether this correctly represents its constitution.

2. When the colouring matter is boiled with alcohol the phenomena are materially different; for the filtered solution deposits, on cooling, a pale flocky amorphous substance, which is obtained pure by repeated crystallization. It is insoluble in water, readily soluble in hot, sparingly in cold alcohol, and scarcely at all in ether. Its analysis gave results which agree with the formula $C_{40}\,H_{34}\,O_8$.

3. The red alcoholic solution from which the flocky matter has been separated leaves an evaporation or dark red amorphous resin, melting at 212°. It gives a red precipitate with acetate of lead, but the compound could not be obtained of definite composition, and it seems not improbable that the resin may be a mixture of several different substances. The author found the proportion of oxide of lead to vary between 18·67 and 34 per cent., according to the conditions under which the precipitation was effected. The resin, on analysis, gave results which agree pretty well with the formula $C_{60}\,H_{30}\,O_{14}$, which is in accordance with the lowest proportion of oxide of lead obtained from its compound, but none of the other results can be brought into relation with it.

The colouring matter of the Rottlera belongs to the class of substantive dyes, and does not require the intervention of a mordant. It gives a very fine flame colour on silk, but to calico, with or without mordants, it gives only a pale fawn colour, entirely devoid of beauty. The author considers it worth the attention of silk dyers in this country.

The following Donations to the Library were announced :—

Journal of the Asiatic Society of Bengal. No. V., 1854. 8vo. —*From the Society.*

The Quarterly Journal of the Geological Society. Vol. X., Part 4. 8vo.—*From the Society.*

Journal of the Statistical Society of London. Vol. XVII., Part 4. 8vo.—*From the Society.*

The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland. No. 48. (N.S.). 8vo. —*From the Society.*

Catalogue of Stars near the Ecliptic, observed at Markree, during the years 1852, 1853, and 1854, and whose places are supposed to be hitherto unpublished. Vol. III. 8vo.—*From the Royal Society.*

The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. Vol. XIX., No. 55. 8vo.—*From the Editors.*

Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften Mathematisch-Naturwissenschaftliche Classe. Bd. XII., Heft 5 ; Bd. XII., Heft 1 und 2, 8vo.

Register zu den ersten X. Bänden der Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe. 8vo.

Jahrbücher der K. K. Central-Anstalt für Meteorologie und Erdmagnetismus. Von Karl Kreil. (Herausgegeben durch die Kaiserliche Akademie der Wissenschaften). II. Bd. 4to.—*From the Academy.*

Annalen der Königlichen Sternwarte bei München. VI. Bd. 8vo.

Magnetische Ortsbestimmungen an verschiedenen Puncten des Konigreichs Bayern und an einigen auswärtigen Stationen. I. Theil. 8vo.—*From the Observatory.*

Magnetische Karten von Deutschland und Bayern. Von Dr J. Lamont. Fol.—*From the Author.*

Transactions of the Linnæan Society of London. Vol. XXI., Parts 2 and 3. 4to.

Monday, 19*th March* 1855.

Colonel MADDEN, Councillor, in the Chair.

The following Communications were read:—

1. Experiments on Colour as perceived by the Eye, with Remarks on Colour-Blindness. By James Clerk Maxwell, Esq., B.A., Trinity College, Cambridge. Communicated by Professor Gregory.

These experiments were made with the view of ascertaining and registering the judgments of the eye with respect to colours, and then, by a comparison of the results with each other, by means of a graphical construction, testing the accuracy of that theory of the vision of colour which analyses the colour-sensation into three elements, while it recognises no such triple division in the nature of light, before it reaches the eye.

The method of experimenting consisted in placing before the eye of the observer two tints, produced by the rapid rotation of a system of discs of coloured paper, arranged so that the proportions of each of the component colours could be changed at pleasure. The apparatus used was a simple top, consisting of a circular plate on which the coloured discs were placed, and a vertical axis. The discs consisted of paper painted with the unmixed colours used in the arts. Each disc was slit along a radius from centre to circumference, so that several could be interlaced, so as to leave exposed a sector of each. The larger discs, about 3 inches diameter, were first combined and placed on the disc, and the smaller, about $1\frac{3}{4}$ inches diameter above them, so as to leave a broad ring of the larger discs visible.

When the top was spun the observer could compare the resulting tint of the outer and inner circles, and by repeated adjustment, perfect identity of colour could be obtained. The proportions of each colour were then ascertained, by reading off on the circumference of the top, which was divided into 100 parts. As an example, it was found on one occasion, that,—

$$\left.\begin{array}{r} \cdot 37 \text{ Vermilion,} \\ + \cdot 27 \text{ Ultramarine,} \\ + \cdot 36 \text{ Emerald green,} \end{array}\right\} = \left\{\begin{array}{l} \cdot 28 \text{ White} \\ + \cdot 72 \text{ Black} \end{array}\right.$$

By experiments on various individuals, it was found (1.) that a good eye could be depended upon within two of these divisions, or hundredths, at most; and that by repetition of experiments the *average* result might be made much more accurate.

(2.) That the difference of the results of experiments on different individuals was insensible, provided the light used remained the same.

(3.) That when different kinds of light were used, or when the resultant tints were examined with coloured glasses, the results were totally changed.

It follows from this that the cause of the equality of the resulting tints is not a true optical identity of the light received by the eye, but must be sought for in the constitution of the sense of sight. The materials for this inquiry are to be found in the equations of colour of which the above is an example, and these are to be viewed in the light of Young's theory of a threefold sensation of colour.

The first consequence of this theory is, that between any *four* colours an equation can be found, and this is confirmed by experiment.

The second is, that from two equations containing different colours a third may be obtained by the ordinary rules, and that this also will agree with experiment. This also was found to be true by experiments at Cambridge which include every combination of five colours.

A graphical method was then described, by which, after fixing arbitrarily the positions of three standard colours, that of any other colour could be obtained by experiments in which it was made to form a neutral gray along with two of the standard colours. In the diagram so formed, the position of any compound tint is the centre of gravity of the colours of which it is composed, their *masses* being determined from the equation, and the resultant *mass* of colour being the sum of the component *masses*. The colour-equations represent the fact that the same tint may be produced by two different combinations. This diagram is similar to those which have been given by Meyer, Hay, and Professor J. D. Forbes, as the results of mixing colours. It is identical with that proposed by

Young, and figured in his *Lectures on Natural Philosophy.* The original conception, however, seems to be due to Newton, who gives the complete theory, with an indication of a construction in his *Optics.*

The success of this method depends entirely on the truth of the supposition that there are three elements of colour as seen by the eye, every ray of the spectrum being capable of exciting all three sensations, though in different proportions. It is at present impossible to define the colours appropriate to these sensations, as they cannot be excited separately. But it appears probable that the phenomena of colour-blindness are due to the absence of one of these elementary sensations, and, if so, a comparison of colour-blind with ordinary vision will show the relation of the absent sensation to those with which we are familiar.

A method was then described, by which one observation by a colour-blind eye was made to determine a certain point representing the absent sensation, which thus appears to be a red approaching to crimson. The results of this hypothesis were calculated in the form of "equations of colour-blindness" between colours which seem to defective eyes identical. These equations were compared with those previously determined from the testimony of two colour-blind but accurate observers, and found to agree with remarkable precision, rarely differing by more than 0·02 in any colour. The effect of red and green glasses on the colour-blind was then described, and a pair of spectacles having one eye red and the other green was proposed as an assistance to them in detecting doubtful colours.

2. Notice of the Occurrence of British newer Pliocene Shells in the Arctic Seas, and of Tertiary Plants in Greenland. In a letter from Dr Scoular of Dublin. Communicated by James Smith, Esq., of Jordanhill.

Dr Scoular writes :—

"I have lately had the opportunity of examining a series of fossils from high arctic latitudes, brought home by Captain M'Lintock, R.N. The series in one sense is extensive, as there are Silurian and oolitic shells, and also other fossils of the tertiary times. Among these last there are some things which, I am sure, will be of interest to you. Among the specimens are some recent and living shells

from Baring's Island, of which I will send you a list when I determine the species. In the meantime, I may state with full confidence that the variety called Mya udevallensis, so common a fossil with us and in Sweden, is still a living species at Baring's Island. The truncated form of the shell, and the palliar impressions, are those of the M. udevallensis, and not those of the modern M. truncata. On the truth of this you may fully rely, and also that the shells were taken with the animal in them.

"In the collection there are also some fossil plants from Greenland. They are not, however, carboniferous; but to my surprise tertiary, and of the same character as those of the Mull formation. I could not find any difference between them and the fossil leaves from Mull, but I cannot at present command the paper by the Duke of Argyll; however, I have not the smallest doubt of the identity of the formation and species."

The following Gentleman was elected an Ordinary Fellow :—

Dr Wyville Thomson, Professor of Geology, Belfast.

Monday, 2d April 1855.

Dr CHRISTISON, Vice-President, in the Chair.

The following Communications were read :—

1.—Account of Experiments to ascertain the amount of Prof. Wm. Thomson's "Solar Refraction." By Prof. C. Piazzi Smyth.

After alluding to the excessive difficulty of ascertaining the presence and nature of a resisting medium in space, by planetary or cometary perturbations, the author reminded the meeting of the statements made in those rooms last year, that one of the consequences to which the dynamical theory of heat had led him, was the necessity of the existence of a medium filling space; that such medium was but an extension of our own atmosphere, and must experience a condensation in the neighbourhood of the sun; and that there must consequently arise a certain refraction of any heavenly body seen through such medium.

Impressed, therefore, with the importance of endeavouring to get by these means some further light in regard to the long vexed ques-

tion of the resisting medium, Professor Smyth had instituted, during the last summer, a series of observations on stars in the neighbourhood of the sun. Atmospheric difficulties had, however, prevented much being done; and in the whole history of the observatory, but one group of observations available for the purpose in view had been found. This, on being subjected to special calculation, has given two results, both confirmatory, and indicating an amount of solar refraction of $0^s{\cdot}04$ in right ascension, at a distance of 12 minutes of time from the sun.

2. On the Extent to which the Theory of Vision requires us to regard the Eye as a Camera Obscura. By Dr George Wilson.

The object of this communication was to combat the current theory of vision, as exercised by vertebrate animals, in so far as it teaches that the light which reaches the retina from without, thereafter passes through that membrane, and is absorbed by the pigment of the choroid behind it.

The author first enumerated the arguments adduced in favour of this view, such as,

1. The difficulty in assigning any other use for the choroid than that of absorbing the light which falls upon it.

2. The advantages known to result in artificial cameræ obscuræ from the internal darkening of their walls.

3. The confusion which must attend visual perception, if the rays by which objects are seen are reflected several times across the chamber of the eye, so as to repeat, on different points of the retina, the image of a solitary object.

4. The painful and imperfect vision known to characterize the human albino.

The author then proceeded to state that a mass of evidence, daily accumulating, had established, beyond question, the certainty that light is reflected from the anterior layers of the retina and from the choroid, and so abundantly, that oculists take daily advantage of the fact, to examine, by means of this light, the deeper internal structures of the eye.

This organ, accordingly, cannot be regarded otherwise than in a limited sense as a camera obscura, and the arguments in favour of

the opposite belief were shown to furnish no substantial support of the current opinion. Thus, the eyes of albino *animals* were found to exercise vision perfectly, although destitute of *pigmentum nigrum;* and the presence of the *tapetum lucidum*, which acts like a concave metallic reflector in the eyes of many creatures, was shown to furnish no obstacle to sight, which, on the other hand, it rendered more acute when light was feeble. The supposed cross reflection of light within the eye was also shown to be a phenomenon which could rarely occur so as to disturb vision, since the majority of the reflected rays would simply retrace the course which they took on entering the eye, and pass out through the pupil as they passed in through it; and the few which diverged so much as to fall on the back of the iris, the ciliary processes and the anterior lateral surface of the choroid, would be caught upon the darkest and least reflecting portion of the interior of the eye, and undergo in greater part absorption, whilst such as were not thus stopped, and those which underwent lateral reflection from the bottom of the eye, would be irregularly dispersed over the entire retina, and only lessen its general sensitiveness without repeating the images of objects on single points of its surface.

The author finally urged that the reflection of light from the bottom of the eye served important ends, especially in the lower animals. Those ends he held to be;—

1. The return from the choroid of light through the retina, so as to double the impression on the latter.

2. The reflection of light on external objects, which was best seen in creatures whose eyes are provided with *tapeta lucida*, and acted alike as an assistance to them in finding their food, and in the case of carnivorous nocturnal and marine animals, to their prey in escaping from them.

In the human subject, it was contended that, in very faint light, reflection from the bottom of the eye would assist vision, and that the known delicacy of visual perception, which characterised those who had been long imprisoned in dark chambers or dungeons, afforded an example of such assistance. The author also insisted on the fact, that, as the reflected light is always coloured, so as in the human eye to be bright red, yellowish-red, or brownish-red, and in different eyes to a different degree; and as we add from our eyes coloured light to every object we gaze at, no two persons see the same colour alike, or will exactly agree in matching tints. The existence

and importance of such a chromatic personal equation was dwelt on at some length.

3. Researches on the Amides of the Fatty Acids. By Thomas H. Rowney, Ph.D., Assistant to Dr Anderson. Communicated by Dr Anderson.

The author in this paper gives the details of an examination of the compounds obtained by the action of ammonia on some of the oils and fats.

The method employed was to mix one volume of the oil, two volumes alcohol, and four volumes of strong aqua ammoniæ in a stoppered bottle, and placing it in a moderately warm situation, the stopper being tied down. Occasional agitation is required. After a time, varying with the oil employed, there is formed a whitish solid matter, which increases in amount as the oil diminishes. Finally, the whole becomes nearly solid.

The mass is collected on a cloth filter, washed with a little water, and squeezed, and the residue dissolved in warm alcohol; the crystals deposited on cooling are washed first with dilute spirit, then water, and again expressed, and this was repeated till a resinous matter was removed, which adheres obstinately to the product.

The amides thus formed, when pure, are white, and permanent in the air, but if any of the resin be present, they soon become yellow and resinous.

The quantity obtained from different oils varied much. The drying oils yield less of the amides and more resin than the fat oils.

The oils hitherto examined are almond oil, linseed oil, poppy oil, cod-liver oil, seal oil, and croton oil, besides almond oil and castor oil after solidification by nitrous acid.

The author describes the properties and gives the analytical details of the amides thus produced, and the results are summed up as follows:—

Linseed oil, Poppy oil, and Croton oil	yield margaramide;	
Almond oil and Seal oil	yield oleamide;	
Castor oil	yields ricinolamide; and	
Almond oil and Castor oil	after solidification by nitrous acid, yield	elaidamide and palmamide;

Which two latter compounds are isomeric with oleamide and ricinolamide.

The melting points of these amides were found as follows :—

Margaramide, , . . .	103° C.	(60° C. Boullay)
Palmamide and Elaidamide,	94° C.	
Oleamide, ...	82° C.	

The author considers the melting points ascribed to ricinolamide (66° C.) and isocetamide (67° C.), by Boullay, are below the truth.

The researches of the author are not yet completed, and the results of experiments now in progress will be given on a future occasion.

Monday, 16th April 1855.

Right Rev. Bishop TERROT, V.P., in the Chair.

The following Communications were read :—

1. Notice of some new Forms of British Fresh-Water Diatomaceæ. By William Gregory, M.D., F.R.S.E., Professor of Chemistry.

The author stated that he had examined, more or less minutely, nearly 300 fresh-water gatherings, and that he had found in these very nearly all the known British species, besides a number not yet described. He mentioned that, from the want of figures, it was often difficult to know whether a form were new or not. Thus, *Pinnularia latestriata*, found by the author two years since in the Mull earth, had been considered as a new species by all British naturalists, as well as several foreign ones; yet in Ehrenberg's last work, "Mikrogeologie" it is figured as *P. borealis*, and as having been described by Ehrenberg ten or twelve years ago. The papers of that author, in the Berlin Reports and Transactions, are not generally accessible. Ehrenberg describes this species as being one of two found scattered in every part of the world, and in almost every locality, more uniformly than any others; which is confirmed by the author's observations in this country. Yet, although a remarkable and conspicuous form, it had escaped notice in Britain till 1852. This shows the necessity of minute search, without which the scattered forms are sure to be overlooked.

The new forms were described in three sections.

I. Species figured by foreign authors, but new to Britain.

1. Eunotia tridentula.
2. Navicula follis (Trochus ?) Ehr.
3. „ dubia, Kütz.
4. „ Bacillum, Ehr.
5. Pinnularia megaloptera, Ehr.
6. „ dactylus, Ehr.
7. „ nodosa, Kütz.
8. „ pygmæa, Ehr.
9. Stauroneis Legumen, Kütz.
10. Stauroneis ventricosa, Ehr.
11. Cocconema cornutum, Ehr.
12. Gomphonema subtile, Ehr.
13. Melosira distans, Ehr.
14. Navicula amphigomphus, Ehr., and
15. „ dilatata, Ehr., possibly varieties of Navicula dubia, not figured by the author.

II. New Species, observed by others, nearly about the same time as by the author, and named by the Rev. Professor Smith, but still MS. species.

16. Navicula apiculata, Sm.
17. „ rostrata, Sm.
18. „ scutelloides, Sm.
19. Mastogloia Grevillii, Grev.
20. Pinnularia hemiptera, Sm. (not figured.)
21. Navicula sufflata, Sm. (Auvergne. Found in Britain by the author. Not figured.)

III. Species now first described and figured.

22. Cymbella (?) sinuata. W. G.
23. „ turgida, W. G.
24. „ obtusa, W. G.
25. „ Pisciculus, W. G.
26. „ Arcus, W. G.
27. Navicula cocconeiformis, W. G.
28. „ lacustris, W. G., do. β.
29. „ lepida, W. G., do. β.
30. „ bacillaris, W. G.
31. „ incurva, W. G.
32. „ longiceps, W. G.
33. Pinnularia gracillima, W. G. (vaciva, Sm.)
34. Pinnularia linearis, W. G.
35. „ biceps, W. G.
36. „ digitoradiata, W. G.
37. „ Elginensis, W. G.
38. „ globiceps, W. G.
39. Stauroneis obliqua, W. G.
40. „ dubia, W. G.
41. „ ? ovalis, W. G.
42. Surirella tenera, W. G.
43. Gomphonema insigne, W. G.
44. „ ventricosum, W. G.
45. „ Sarcophagus, W. G.
46. „ æquale, W.G.

The following numbers refer to figures of the varieties of Navicula elliptica, Kütz :—

47. Navicula elliptica, Kütz.
48. „ „ var. β
49. Navicula elliptica, var. γ
50. „ „ var. δ

The whole of the above species, with the few exceptions above noted, were illustrated by highly finished drawings, made from nature by Dr Greville, and enlarged to a scale of 10,000 times the natural linear dimensions.

The author concluded by making some observations on the distribution of fresh-water Diatoms, and showed by various examples that it is often quite easy to determine the characters of a species, if these be well marked, even when it occurs sparingly or scattered, and that when a form is once noticed, we are pretty sure to find it soon after in greater abundance. To show the value of minute search, he stated that although most of the above new species occurred in several gatherings, yet in point of fact, nearly the whole of them had been

observed in a detailed exploration of only four gatherings, those, namely, from Elgin, Elchies, Lochleven, and Duddingston Loch. Nay, he had found them all, except only one or two, by degrees, in the Lochleven gathering alone, and a very large proportion of them in each of the three others. So that, if his observations had been confined to these four gatherings, or even to that of Lochleven, it would have been possible to recognise and distinguish nearly all the species here mentioned.

The above list of forms is entirely exclusive of those very numerous and varied ones, occurring, however, in many of the gatherings examined by the author, as above described, which he has elsewhere united together, described, and figured, under the name of Navicula varians.

The figures of Navicula elliptica, Kutz., and its very striking varieties, as the author had observed them in the study of these gatherings, were referred to, in order to prove that certain species vary not only in form or outline, as in the case of Navicula varians, Pinnularia divergens, and many others, but also in general aspect, in the number of striæ in $\frac{1}{1000}$th of an inch, comparing two frustules of equal size, in the structure of the median line, and in that of the central or terminal nodules.

2. On Glacial Phenomena in Peebles and Selkirk Shires. By Robert Chambers, Esq., F.R.S.E., &c.

In this short paper, the author presented facts, from which he thought himself entitled to infer that the Silurian mountain tract of southern Scotland falls entirely into his views regarding ancient glacial operations in the country generally, as expounded in a paper read to the Royal Society of Edinburgh, in December 1852, and published in the *Edinburgh New Philosophical Journal* for April 1853. He showed that the compact boulder clay, which he regards as the detritus of the early and general *glaciation* of the country, exists in the valleys of this district, and in passes amongst the hills, up to those of Glenlude and Tweedshaws, which are respectively 1152 and 1352 feet above the mean level of the sea. Striated boulders from Glenlude and Tweedshaws were brought before the Society. The rounded form of the hills, and the horizontal *mouldings* or *flutings* which are seen along the faces of many of them, he con-

siders as other memorials of the operation in question. The nature of the rocks is unfavourable for the preservation of smoothed and striated surfaces; but Mr Chambers had found one such on the border of St Mary's Loch in Selkirkshire, 800 feet above the sea. On the assumption that the hills had been shorn and rounded by moving ice, it appeared from the high inclination of the strata, as exhibited in a copy of Professor Nicol's section of the district, that the amount of denudation fully equalled the remarkable examples adduced by Professor Ramsay in regard to South Wales and the Mendip hills. Finally, Mr Chambers described an example of the later and limited operations of ordinary glaciers, in the elevated moor of Loch Skene, a tarn formed and retained by a moraine.

3. Preliminary Notice on the Decompositions of the Platinum Salts of the Organic Alkalies. By Thomas Anderson, M.D., Regius Professor of Chemistry in the University of Glasgow.

The following pages are intended merely as a preliminary notice of an investigation, which has occupied me for some time past, and which, though still too incomplete for publication in full, is sufficiently advanced to render obvious the general character of the results, although, from the extensive and elaborate nature of the inquiry, a very considerable time must elapse before it is complete in all the requisite details.

It has been known for some years that the platinum salts of the organic alkalies are decomposed when boiled with excess of bichloride of platinum; and with narcotine, the only one as yet examined, the action is a true process of oxidation, yielding results similar to those obtained by treating the base with peroxide of manganese or nitric acid. The present investigation refers to the pure platinum salts, which undergo an entirely different decomposition, the nature of which is materially dependent on the stability of the base. Having observed that the decomposition was more precise and definite when the less decomposable bases were employed, and apparently calculated to afford the key to the more complex changes, which occur in other cases, I have hitherto directed my attention more particularly to pyridine and picoline, which are so remarkable for their stability,

and especially for the obstinacy with which they resist the action of oxidizing agents.

When the platinum salt of pyridine, carefully freed from excess of bichloride of platinum is dissolved in hot water, and the solution kept steadily boiling for some hours, a fine sulphur yellow crystalline powder begins to appear. After five or six days' continuous boiling the whole of the platinum salt is converted into this substance, but if the powder be filtered off before the change is complete, the mother liquid on cooling gives a deposit of fine golden-yellow scales resembling iodide of lead.

The yellow powder is insoluble in water and acids, and is decomposed by potash slowly in the cold, more rapidly on boiling, with the evolution of pyridine. It is the salt of a platinum base, analogous to platinamine, to which I give the name of platinopyridine. Its analysis gave—

	Expt.	Calculation.		
Carbon, . . .	24·30	24·12	C_{10}	60·
Hydrogen, . . .	2·14	2·01	H_5	5·
Nitrogen, . . .	...	5·65	N	14·
Chlorine, . . .	28·56	28·54	Cl_2	71·
Platinum . . .	39·60	39·68	Pt	98·7
		100·00		248·7

It is therefore a bihydrochlorate of platinopyridine, with the formula $C_{10}\,H_3\,Pt\,N + 2\,H\,Cl$, and the decomposition which yields it consists simply in the expulsion of an equivalent of hydrochloric acid, as represented by the equation

$$C_{10}\,H_5\,N,\,H\,Cl\,Pt\,Cl_2 = C_{10}\,H_3\,Pt\,N + 2\,H\,Cl + H\,Cl.$$

The equivalent of hydrochloric acid escapes with extreme slowness, but the change may be much facilitated by the addition of a sufficient quantity of pyridine to combine with it, although an excess must be carefully avoided, as it produces a different decomposition, to be afterwards described.

Platinopyridine cannot be separated from the bihydrochlorate by alkalies, but when boiled with salts of silver, the corresponding salts of the base are obtained. The decomposition, however, is very slowly effected, and certain changes occur which I am not yet in a condition satisfactorily to explain. When the hydrochlorate is boiled with two equivalents of sulphate of silver, it gradually loses its

colour, and the yellow solution produced contains the sulphate of platinopyridine, which is extremely soluble in water, and dries up into a gummy mass on evaporation. Considerable difficulties have been encountered in obtaining the salts of platinopyridine in a state fitted for analysis, and the only one which has given satisfactory results is the chromate, which is obtained on adding bichromate of potass to the sulphate, in the form of a fine orange-red precipitate, having the formula C_{10} H_3 Pt N HO CrO_3.

When the bihydrochlorate of platinopyridine is boiled with two equivalents of sulphate or nitrate of silver for a shorter time than is requisite for its complete decomposition, and the chloride of silver collected on a filter, washed and treated with ammonia, it leaves behind a yellow crystalline matter, generally in small quantity. This substance is insoluble, or nearly so, in water, but dissolves in boiling nitric acid, from which it is deposited, on cooling, in beautiful shining plates. It contains chlorine, but I have not yet succeeded in explaining its constitution.

The golden yellow scales produced when the ebullition of the platinum salt of pyridine is stopped before the change into platinopyridine is complete, have a very singular constitution, the analysis giving—

	Expt.	Calculation.		
Carbon, . . .	22·70	23·47	C_{20}	120·
Hydrogen, . .	2·30	2·06	H_{11}	11·
Nitrogen, . . .	...	5·26	N_2	28·
Chlorine, . . .	32·75	33·24	Cl_5	177·5
Platinum, . . .	36·61	36·97	Pt_2	197·4
		100·00		533·9

and its formula is—

$$C_{10} H_5 N H Cl Pt Cl_2 + C_{15} H_3 Pt N 2H Cl,$$

representing it as a double compound of the original platinum salt and the bihydrochlorate of platinopyridine. I refrain at present from discussing its nature.

When the platinum salt of pyridine is boiled with an *excess* of pyridine, the fluid becomes extremely dark-coloured, and on evaporation to dryness in the water-bath and addition of water, a dark solution is obtained, and a crystalline residue left, which is very sparingly soluble in water, more so in boiling alcohol, and is deposited

on cooling in small needle-shaped crystals. Its composition was found to be—

	Expt.	Calculation.		
Carbon, . .	28·31	28·14	C_{10}	60·
Hydrogen, . .	2·48	2·34	H_5	5·
Nitrogen, . .	...	6·58	N	14·
Chlorine, . .	16·69	16·65	Cl	35·5
Platinum, . .	45·83	46·29	Pl	98·7
		100·00		213·2

This corresponds with the formula $C_{10} H_4$ Pt N + HCl, which is that of a hydrochlorate of platosopyridine corresponding to the hydrochlorate of platosamine. By treatment with nitrate and sulphate of silver the salts of these acids are produced.

The picoline platinum salt decomposes very slowly, but after eight or ten days' boiling a platinopicoline is produced. If a little picoline be added to the solution, the change is complete in a few hours. The bihydrochlorate is insoluble in water, and the double compound containing that substance in combination with the original salt, and of which the formula is

$$C_{12} H_7 N H Cl Pt Cl_2 + C_{12} H_5 Pt N 2H Cl,$$

crystallizes in grains, and is much less soluble than the corresponding pyridine compound. The properties of these substances will be afterwards fully described.

The platinochloride of ethylopyridine is very slowly decomposed by boiling, but eventually a substance is deposited which as yet has given only discordant results. A small quantity of pyridine appears to promote the decomposition, but the most remarkable effect is produced by the addition of ammonia. The solution in this case is completely decolorized by a few minutes' boiling, and it then gives a white precipitate on the addition of carbonate of ammonia. The substance so obtained is very sparingly soluble in water, and almost insoluble in alcohol. Analysis showed it to be Raewski's carbonate, the sesquihydrochlorocarbonate of diplatinamine. The action of ammonia is readily explained by the equation

$$C_{14} H_9 N H Cl + Pt Cl_2 + 2HN_2 = N_2 H_4 Pt HCl + C_{14} H_9 N HCl.$$

The salt, $N_2 H_4$ Pt HCl, was separated from the fluid and examined; it appears to be identical with the substance obtained by Gerhardt by the action of ammonia on the platinochloride of ammonium.*

The details of these, and other decompositions, I reserve to a future time; meanwhile I shall content myself with stating that most of the platinum salts examined are decomposed by sufficiently protracted ebullition, although some are extremely stable.

The platinum salt of ethylamine is scarcely changed when boiled alone, but in presence of excess of base, a substance is produced, sometimes in yellow, and at other times in purple crystals, which become yellow at 212°. It appears to be the hydrochlorate of platosethylamine.

The aniline compound is very easily decomposed, but the products do not appear to be definite.

The narcotine compound dissolves in a considerable quantity of hot water, and on boiling the solution at first remains unchanged; after some hours, however, it acquires a brown colour, and, a few minutes' longer boiling, a black precipitate, containing the whole of the platinum, but combined with some organic matter, is deposited. The filtered fluid, on addition of ammonia, gives a precipitate resembling narcotine, but whether it is that base, or a product of decomposition, I have not determined.

The brucine compound is very sparingly soluble, but if boiled with water is at length decomposed, with the production of a black powder; on filtering a red solution is obtained, which deposits a yellow platinum salt on cooling. It is possible, however, that this may be merely a portion of the original salt, for as soon as the undissolved portion had become black I filtered the solution.

I shall not at present enter on the consideration of the inferences to be drawn from this investigation, further than to observe that it is likely to modify to some extent certain of the views now entertained regarding the constitution of the bases. In the third part of my investigation of the products of the destructive distillation of animal substances, I have shown that pyridine and picoline, by taking up a single atom of the alcohol radicals, are converted into fixed bases, so that according to the ordinarily received opinion, they are nitryl bases in which the whole of the hydrogen is replaced by these

* Comptes Rendus des Travaux Chimiques, 1849, p. 113.

different radicals. The production of the platinum bases, however, shows that they do still contain replaceable hydrogen, so that either the formation of a fixed base by the addition of one equivalent of a radical does not prove that they are nitryl bases, or the received opinion regarding the constitution of the platinum bases must undergo some modification.

It is clear that at present we cannot attempt any explanation of these apparently anomalous results; but I am now engaged examining the decompositions of the platinum salts of amide and nitryl bases containing known radicals, which will probably lead to their correct explanation.

4. On the Volatile Bases produced by Destructive Distillation of Cinchonine. By C. Greville Williams, Assistant to Professor Anderson, Glasgow University.

In this paper the author shows that Cinchonine by distillation with potash, undergoes a very complex decomposition, and that instead of yielding one base, as has hitherto been supposed, gives at least seven.

The mode of research at first adopted was to convert the basic liquid into platinum salt, and separate the bases by fractional crystallization in the manner described in his paper "On the Presence of Pyridine in the Naphtha produced by destructive distillation of the Bituminous shale of Dorsetshire."*

The experiments made in this manner, indicated that several substances were present, but it was evident that to decide the question, a very large amount of material would be required; the author therefore subjected 100 ounces of cinchonine to distillation with potash, and thus obtained sufficient of the basic oil to enable him to effect twelve complete fractionations, involving at least 240 distillations.

Runge's Pyrrol was present in the crude bases, and was removed by protracted boiling of the acid solution.

The bases were procured free from water by digestion with potash. The following fractions were then analysed.

Fraction boiling at 310° *F.* The basic liquid on analysis gave numbers exactly agreeing with the formula,

$$C^{14} H^{9} N,$$

* Philosophical Magazine, Sept. 1854.

which is that of Lutidine, a base which has, as yet, only been twice observed before, it having been discovered in Dippel's animal oil by Dr Anderson, and found soon after in Shale Naphtha by the author of the present paper. Pyridine and picoline were also found by fractionally crystallizing the platinum salts obtained about this point in the earlier distillations, but the quantity present was extremely small.

Fraction boiling between 350° *and* 360° *F.* This fraction was found to consist of collidine, a platinum salt giving on combustion numbers agreeing closely with the theoretical values. Collidine was also found in fractions boiling as high as 380° to 390°.

Fraction boiling between 410° *and* 420° *F.* Five analyses of platinum salts obtained at this point indicated the base present to possess the formula,

$$C^{18}\,H^{7}\,N,$$

being the chinoline of Gerhardt. The author proposes in a future paper to compare Chinoline with the Leukoline of Hofmann, with a view of determining the question of their being identical, or merely isomeric. Chinoline forms by far the greater portion of the basic liquid.

Fraction boiling between 510° *and* 520° *F.* This was found to consist of a new base, which the author terms Lepidine, the formula of which, derived from analyses of the double salt with bichloride of platinum, the hydrochlorate, nitrate, bichromate, and also the hydriodate of the amyl compound, is

$$C^{20}\,H^{9}\,N,$$

the experimental numbers in each case agreeing closely with those required by theory.

The author states his belief that several bases said to be the sole products of certain reactions, as well as some natural ones, will be found to be mixtures, and he is now examining nicotine with a view to ascertain whether it is a homogeneous body ; he also gives the results of some experiments proving pyrrol to be produced by destructive distillation of many nitrogenous bodies, and concludes with

the following table of the substances analysed by him in the course of the investigation,—

Platinum salt of Pyridine, . .	$C^{10} H^5N, HCl, Pt Cl^2$
" " Picoline, . .	$C^{12} H^7 N, H Cl, Pt Cl^2$
Lutidine, ...	$C^{14} H^9N.$
Platinum, Salt of Lutidine, . .	$C^{14} H^9N, H Cl, Pt Cl^2$
" " Methyllutidine, .	$C^{16} H^{11}N, H Cl, Pt Cl^2$
" " Collidine, . .	$C^{16} H^{11}N, HCl, Pt Cl^2$
" " Chinoline, . .	$C^{18} H^7N, H Cl, Pt Cl^2$
Lepidine, ...	$C^{20} H^9N,$
Platinum salt of Lepidine, . .	$C^{20} H^9N, H Cl, Pt Cl^2$
Hydrochlorate of Lepidine, . .	$C^{20} H^9N, HCl.$
Nitrate of Lepidine, . . .	$C^{20} H^9N, NO^5, HO.$
Bichromate of Lepidine, . . .	$C^{20} H^9N, 2Cr O^3, HO$
Hydriodate of Amyllepidine, . .	$C^{30} H^{19} N, HI.$

Monday, 30th April.

The Very Rev. Principal LEE, V.P., in the Chair.

The following Communications were read:—

1. Remarks on the Coal Plant termed Stigmaria. By the Rev. Dr Fleming.

The author, after noticing the proofs of Stigmaria being the root of Sigillaria, called attention to the external organs, known formerly as the leaves, and more recently as the rootlets of the former. He stated that in the many examples of stigmaria which he had examined, he had never observed these rootlets articulated to the stem by anything resembling a ball-and-socket joint, considering the appearance which had led to this notion as due to shrinkage and state of preservation.

The views of Dr Hooker, as given in his valuable paper on Stigmaria in the "Memoirs of the Geological Survey," vol. ii., p. 437, were next considered. This acute observer, from an examination of a particular specimen, concluded that these rootlets, *within* the body of the stem, form obconical or flaggon-shaped bases, the sum-

mits of which are on a level with the mouths of the cavities in which they are contained.

In the two specimens which Dr Fleming exhibited from the Boghead parrot coal,* it clearly appeared that the rootlets communicated directly with the body or trunk, which in this case had been filled from within, with the pulpy matter of the coal, and had thus entered the tubular rootlets which extended for some distance into the argillaceous matter on the outside. Hence he inferred that the flaggon-shaped bodies noticed by Dr Hooker were the lower portions of the rootlets, not in the inside, but on the *outside* of the stigmaria.

The author next called the attention of the Society to a statement in Dr Traill's paper on Bitumenite published in the last part of the Transactions, vol. xxi., p. 10, by which it appeared that "A very magnificent specimen of stigmaria in bitumenite (the name given to the Boghead Parrot), as thick as the human body, had been deposited by Dr Christison in the University Museum." The unusual dimensions here assigned to stigmaria led the author to inspect the specimen, when it was found to be a sigillaria similar to the one which he exhibited from the same coal.

Dr Fleming next exhibited examples of the different *quantities* of coal produced by stigmaria, sigillaria, favularia, calamite, sternbergia, and lepidodendron, observing that as these plants can furnish coal-making materials *separately*, and as their remains exist in coal, it cannot be denied that, in the *aggregate*, they would be equally productive; nor, with these facts in view, could it be maintained that coal can only be formed from fir or allied woods.

The author then proceeded to observe that in ordinary household coals, such as caking, cherry, or splint, each bed is stratified, and the strata are separated at their *partings* by patches of fibrous anthracite, as if formed from broken portions of woody matter. These partings indicate a recurring intermittency of action, probably arising from *season changes* during the accumulation of vegetable matter in a form analogous to peat. The parrot coals, on the other hand, by the absence of stratification (being merely laminated or slaty parallel with

* This valuable coal was dug and sold from the lands of Boghead, and known as the Boghead Parrot or Gas Coal, years before its existence in the lands of Torbanehill was ascertained, and, therefore, as a designation, has the undoubted claim of priority.

the plane of stratification of the neighbouring sedimentary rocks), indicate a more decidedly simultaneous origin, and appear to have been in the state of disintegrated vegetable matter, mixed more or less with earthy mud, and distributed like the beds of sandstone and clays. That these coals were originally clays into which bituminous matter was injected will not be countenanced by any one acquainted with their structural character, contents and relative position. There is no bitumen in the Boghead parrot, nor any substance analogous to what has been termed ozokerite from Binny Quarry, to which Dr Bennett has referred. The last substance, indeed, melts at a heat considerably below that of boiling water.

The pulpy condition of the original material of the parrot coals, must have been favourable for molecular changes usually termed metamorphic, which may have so far modified the forms and structures of the vegetable tissues as to give them a segregated or concretionary character.

The author concluded by expressing his regret that Dr Traill, after the discussions which have taken place in the Society should have carried his opinion, that the Boghead parrot was a new *mineral species*, to which he has given the name of Bitumenite, so very far as to have published it towards the beginning of the last part of the Transactions already referred to; for the material in question is neither chemically, optically, nor mechanically homogeneous, as demonstrated in the papers of Professors Bennett and Balfour at the close of the same part of the Transactions.

2. On Errors caused by Imperfect Inversion of the Magnet in Observations of Magnetic Declination. By William Swan, Esq.

The direction of the Magnetic Meridian, as indicated by that of a freely suspended magnetized needle will generally be erroneous, unless the magnetic axis of the needle is parallel to its axis of figure; and hence, in order to obtain an accurate value of the magnetic declination, it becomes necessary to take the mean of two observations of the needle, first suspended in its usual position and next inverted. If, however, the inversion of the needle is not accomplished with perfect accuracy, the correction, for want of parallelism between the magnetic axis of the needle, and its axis of figure, will not be complete; and the value of the magnetic declination obtained from the

mean of two observations of the needle, first in its usual position, and then inverted, will be affected with a residual error due to imperfect inversion of the needle. The present investigation refers chiefly to that form of declinometer magnet, in which the magnet is converted into a collimator by attaching to it a lens and cross fibres or a divided glass scale, in the principal focus of the lens.

It is shown that the errors due to imperfect inversion may be computed, provided the magnet is observed, not only in its usual position, and then inverted,—that is turned 180° round its axis,—but also, when turned round 90° and 270°.

Putting δ for the correct reading, for the magnetic meridian on the limb of the theodolite, used in observing the magnet; δ_1, δ_2, δ_3, δ_4, for the readings, when the magnet is turned through 0°, 90°, 270°, 360° respectively; and ε for the correction to be applied to the value of the magnetic declination got from the mean of the readings in the erect and inverted positions of the magnet,

$$\delta = \tfrac{1}{2}(\delta_1 - \delta_3) - \varepsilon.$$

The value of ε in seconds of arc may then be computed with sufficient accuracy by the following formulæ—

$$\tan\beta = \frac{\sin\frac{1}{2}(\delta_1 - \delta_3)}{\sin\frac{1}{2}(\delta_4 - \delta_2)}$$

$$\sin\alpha = \frac{\sin\frac{1}{2}(\delta_1 - \delta_3)}{\sin\beta} = \frac{\sin\frac{1}{2}(\delta_2 - \delta_4)}{\cos\beta}$$

$$\varepsilon_1 = \frac{\sin\alpha\cos\frac{1}{2}(\beta_1 + \beta_3)\sin\frac{1}{2}(\beta_1 - \beta_3)}{\sin 1''\sin\psi\cos\frac{1}{2}(\delta_1 - \delta_3)}$$

$$\varepsilon_2 = \frac{\sin\alpha\cos\frac{1}{2}(\psi_1 + \psi_3)\sin\frac{1}{2}(\psi_1 - \psi_3)}{\sin 1''\sin\psi_1\sin\psi_3\cos\frac{1}{2}(\delta_1 - \delta_3)}$$

$$\varepsilon = \varepsilon_1 + \varepsilon_2;$$

Where $\beta_1 = \beta + \gamma_1$; $\beta_3 = \beta + \gamma_3$;

γ_1, γ_3, ψ_1, ψ_3 and ψ, being angles found by actual observation.

3. On the Accuracy attainable by means of Multiplied Observations. By Edward Sang, Esq.

On opening any astronomical work of the present day, we are at first startled by, and then familiarized with, the excessive precision of the numbers set down. In our Nautical Almanac, for example,

although referring to a period three or four years subsequent to the date of publication, the declinations of the stars and planets are set down to tenths of a second of arc, and their right ascensions to hundredths of a second of time.

Similarly in tables of the geographical positions of observatories, we find the latitude and longitude often given to the same degrees of precision; an accuracy which would affect to discriminate between the latitudes of the two ends, or the longitudes of the two sides of a dining table.

Yet it is very much to be doubted if any astronomical instrument exist, which, by a single observation, is capable of giving the altitude of a star, or the latitude of a place, true to the nearest second; and it is also very much to be questioned, whether any ear, however practised, has acquired such delicacy of perception as to note the instant of an expected occurrence true to the nearest tenth of a second.

Now, astronomers draw the most important conclusions from the measurements of minute quantities. Thus, the absolute distances of the sun and planets are determined from the measurement of an angle of 8 or 9 seconds, and which is set down as being accurately $8''\cdot5776$, the unimaginable precision of the last figure being obtained by Professor Encke from observations made in 1761, 1769.

The linear velocity of light, again, is computed from observations on an angle of some $40''$; our knowledge of the relative masses of the planets is founded on the measurement of minute disturbances, and our wide guess at the distance of the fixed stars relies on the perception of a single second of annual parallax amid a heap of uncertainties of precession, nutation, and proper motion.

It is then of some importance to inquire into the degree of confidence which ought to be placed in such excessively minute determinations, and to distinguish between that degree of precision to which we have actually attained, and that imaginary exactitude which is the result of arithmetical operations.

The common method of determining any quantity to an extreme degree of precision, is to measure that quantity very often, and then to take the arithmetical mean of the multitude of discordant results, it being understood that some principle of compensation exists which renders the mean more trustworthy than any of the actual observations from which it has been obtained.

It has been plausibly argued against this proceeding that as the

mean rarely coincides with any of its constituents, all the evidence goes to show that it is *not* the true result. Without, however, stopping to examine the logical, I proceed to weigh the logistic, argument which bears upon the matter.

In order to have a case before me, I shall take, as a fair example of this method, the determination of the latitude of Padua by the celebrated astronomer, Giovani Santini, in 1811. His process was to observe the instants when several stars of various declinations reached a fixed altitude; by which means he depended only on the going of his clock and the verticality of the axis of his instrument. From sixteen sets of such observations he obtained the following results with their mean.

I.	45°	23′	56· ″	X.	45°	23′	59·4″
II.	45	24	5·7	XI.	45	23	59·
III.	45	24	4·6	XII.	45	24	4·1
IV.	45	23	56·0	XIII.	45	24	4·4
V.	45	24	7·2	XIV.	45	24	3·0
VI.	45	24	5·2	XV.	45	23	58·5
VII.	45	24	3·1	XVI.	45	24	0·7
VIII.	45	24	3·2				
IX.	45	24	4·5	Medio di tutti	45	24	2·16

Now, on glancing at these numbers, we observe that two of them are no less than 6″·16 below, and one 5″ above the mean; and these variations would seem to show, not that we have obtained a latitude which can be depended upon to the nearest second, but that the observations are not to be trusted to nearer than ten seconds; and amid these disagreements, Signor Santini's concluding remark sounds strangely,

"Si può pertanto stabilire la latudine dell' osservatorio di Padova in numeri rotondi 45° 24′ 2″."

It would seem that, unless these results have been connected together by some law that would insure the compensation of errors, the only conclusion that we are entitled to come to is, that the latitude of the Observatory of Padua is between 45° 23′ 56″ and 45° 24′ 0·7″.

Taking, then, this example as a general type of such proceedings; I observe that there are two distinct sets of cases; viz., those where

a known law of compensation exists; and those in which the separate observations and their errors are independent of each other.

Thus, when we repeat the measurements of an angle upon different parts of a circle, we are certain that, however erroneous the division may be, the entire circumference is 360, and that, therefore, an error of defect in one part, implies one of excess in another part of the limb. Again, if we read at three or five places equidistant from each other, we know that that part of the inaccuracy which arises from the eccentricity of the fittings, is eliminated. Or if we take an altitude face East and then face West, we know that the two errors arising from a misplacement of the zero compensate for each other. But in all those cases where the compensating principle exists, a result from which any of the compensating quantities is excluded, cannot be considered as that of a complete observation; thus an altitude face East, without its complementary altitude face West, could not be used to found upon; and those only in which the compensating principle has had full scope, can be admitted to be observations.

Thus it seems that our attention need only be given to those cases in which no law of compensation is known to exist: of which our example is one.

As there existed no particular reason why one set of stars should have been taken rather than another, Signor Santini might have chanced to make only observations I. and IV., and he would have had strong reason to believe the latitude to be 45° 23′ 56″; or if the weather had permitted him to make only observations III., IX., XII., and XIII., he would have concluded that the true latitude is 45° 24′ 04″. Within the limits of the errors to which the particular class of observations is liable, it is difficult to adduce any argument in favour of one rather than another, in fact, it is a matter of accident, what result is arrived at.

That we may have a clear view of the subject, suppose that, in order to measure a given angle, a circle is used of, say, 30 inches diameter, divided to 10″, and carrying a telescope powerful enough to render an angle of 10″ quite appreciable; suppose also, that the graduation is perfect, and that by the first observation the angle comes out so many degrees, minutes, and say 40″. If we measure the angle again we shall obtain the same result 40″; and if again and again, and again, still the same 40″; and it is quite clear, that

however often we may repeat the observation, the mean will still remain 40″. Yet all the while the true angle may be 41, 42, 43, or even 44″; and it would appear that with such an instrument, an infinity of observations could give us no better a result than a single one.

But if I apply to the same purpose a ten-inch circle carrying a twelve-inch telescope with which 10″ can only be estimated, and having its graduation pushed somewhat beyond the limits of workmanship, I find my measurements to fluctuate from 20″ to 60″. Then the advantage of multiplied observations becomes apparent, and twenty operations give us a result different from that given by ten; and if we admit this system of averaging, we are carried to the absurd conclusion that a small instrument gives more exact results than a large instrument does.

In truth, this averaging of multiplied observations is a fallacy; if the results agree, the averaging is useless; if they do not agree, their discordance affords evidence that the means employed are insufficient to procure the accuracy aimed at.

The same remarks apply to time-observations. To observe the meridian passage of a star we note the instant of its appulse to each of the vertical wires, add the results and take the mean, so that if there be a considerable number of wires, great precision is expected. Now, at each wire we can only, and with hesitation, note the time to the nearest tenth of a second. Suppose that we can do so absolutely, and imagine the wires so placed, that the time of passing from the one to the other is exactly a number of tenths. Then, if the true time of appulse to the first wire were, ·04″, the observed would differ from the true by .04″ at each one of the wires, and the mean would err also by that quantity. Now, there are many declinations which give the interval of passage from wire to wire an exact number of tenths, so that, even supposing the ear perfect to the nearest tenth of a second, there must be many cases in which the average may be ·04″ wrong.

Taking into account the various sources of error in the graduation and adjustment of instruments, we can scarcely assume that the declination of any star is known certainly to half a second of arc, or its right ascension to the twentieth second of time; and it appears that the true use of multiplied observation is to guard against blunders in reading off, and to indicate the degree of confidence which is

to be placed in our results. A quantitative statement in any branch of physical science should give, along with the numerical result, the limit or probability of error, and conclusions drawn from such numbers ought to be made with the probabilities of error full in view. Increased exactitude is only to be obtained by improvements in the means of observing.

The subject may be presented in another light. Assuming that there is some unknown influence tending to derange our otherwise *perfect* observations, we may try to obtain some estimate of its amount. If we were to take the errors as indicating the intensity of the influence, the sum of these errors being zero when the mean is assumed as true, would give zero for the entire influence, hence we must take, with Legendre, the square of the error as the measure of intensity. In this way, the sum of the squares of the deviations from the mean may represent the entire force of the deranging influence, and thence the deranging influence on one observation may be estimated. Following this mode with Santini's latitudes, we find 3″·34 as the probable error; but whether this is to be regarded as the probable error of all, or of one of the observations, is not very clear: indeed the whole doctrine is hypothetical. If we grant the soundness of the method of minimum squares, it is easy to show that the probable or possible error of the result is about three-tenths of the ultimate division of the apparatus.

The following Gentleman was elected an Ordinary Fellow:—

Dr Wright, F.G.S., of Cheltenham.

Monday, 16th April 1855.

Monday, 30th April 1855.

PROCEEDINGS

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1855–56.

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